The Hidden Lives of Nurses' Cognitive Artifacts

Jacquelyn W. Blaz[1]; Alexa K. Doig[2]; Kristin G. Cloyes[2]; Nancy Staggers[2]
[1]School of Nursing, University of Wisconsin-Madison; [2]College of Nursing, University of Utah

Keywords
Workarounds and unanticipated consequences, cognition, electronic health records and systems, nursing notes, inpatient care, provider-provider handoff communication

Summary

Background: Standardizing nursing handoffs at shift change is recommended to improve communication, with electronic tools as the primary approach. However, nurses continue to rely on personally created paper-based cognitive artifacts – their "paper brains" – to support handoffs, indicating a deficiency in available electronic versions.
Objective: The purpose of this qualitative study was to develop a deep understanding of nurses' paper-based cognitive artifacts in the context of a cancer specialty hospital.
Methods: After completing 73 hours of hospital unit field observations, 13 medical oncology nurses were purposively sampled, shadowed for a single shift and interviewed using a semi-structured technique. An interpretive descriptive study design guided analysis of the data corpus of field notes, transcribed interviews, images of nurses' paper-based cognitive artifacts, and analytic memos.
Results: Findings suggest nurses' paper brains are personal, dynamic, living objects that undergo a life cycle during each shift and evolve over the course of a nurse's career. The life cycle has four phases: Creation, Application, Reproduction, and Destruction. Evolution in a nurse's individually styled, paper brain is triggered by a change in the nurse's environment that reshapes cognitive needs. If a paper brain no longer provides cognitive support in the new environment, it is modified into (adapted) or abandoned (made extinct) for a different format that will provide the necessary support.
Conclusions: The "hidden lives" – the life cycle and evolution – of paper brains have implications for the design of successful electronic tools to support nursing practice, including handoff. Nurses' paper brains provide cognitive support beyond the context of handoff. Information retrieval during handoff is undoubtedly an important function of nurses' paper brains, but tools designed to standardize handoff communication without accounting for cognitive needs during all phases of the paper brain life cycle or the ability to evolve with changes to those cognitive needs will be underutilized.

Correspondence to:
Jacquelyn W. Blaz, PhD, MS
School of Nursing
University of Wisconsin-Madison
701 Highland Ave
Madison, WI 53705
Email: blaz@wisc.edu

Appl Clin Inform 2016; 7: 832–849
http://dx.doi.org/10.4338/ACI-2016-01-RA-0007
received: January 13, 2016
accepted: July 30, 2016
published: September 7, 2016
Citation: Blaz JW, Doig AK, Cloyes KG, Staggers N. The hidden lives of nurses' cognitive artifacts. Appl Clin Inform 2016; 7: 832–849 http://dx.doi.org/10.4338/ACI-2016-01-RA-0007
Funding
This project was supported by grant number R36HS022183 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality.

1. Background

Nurses are known to produce their own personalized objects to organize information during a shift [1–6]. These paper objects are recognized as cognitive artifacts – tools that provide cognitive support by offloading a portion of the cognitive work required to do a task from a human mind to an external object [7-9]. Cognitive artifacts can be viewed as part of a distributed cognition system where interactions among individuals, artifacts and information exchange are integrated [10, 11]. Though previous research has characterized nurses' cognitive artifacts as "handoff tools" [12–21], nurses themselves are more likely to use a colloquial term such as "scraps," "cheat sheet," or "brains" [1, 5, 6, 8]. The term brains implies a deeper purpose for these objects beyond mere information during a handoff, thus the term "paper brain" will be used in this manuscript to represent nurses" personalized cognitive artifacts.

Interest in handoffs increased after 2006 when the Joint Commission made improving handoff communication a patient safety goal [22]. Handoff refers to the transfer of information, responsibility, and authority for patient care from one clinician to another during the continuum of care [21]. Standardizing free-form handoff tools was suggested as a strategy to improve efficiency of giving report at the end of a shift [23]. This led to a focus on the content and computerization of handoff tools in the research literature, and thus a technical and functional focus on nurses' brains [7, 8, 19, 24]. However, researchers observed that nurses will continue to use paper brains, even when an electronic handoff tool, designed with nurse input and linked to the electronic healthcare record (EHR) was available [5, 6]. Research has also demonstrated that nurses use their paper brains throughout an entire shift [1, 2, 4–7] versus only at its beginning and end. It is possible that standardized handoff tools, especially electronic tools, have not been more widely adopted because nurses' paper brains and their functions are not fully understood. Standardized tools designed to incorporate the entire range of purposes have greater potential to be adopted that those that do not. Therefore, an understanding of the production and use of nurses' paper brains is imperative because a standardized tool must support fundamental users' needs or it is doomed fail or at least to be underutilized [25, 26].

2. Objective

The purpose of this qualitative study was to develop a deep understanding of nurses' paper brains in the context of a medical oncology unit at a cancer specialty hospital.

3. Methods

3.1 Study Design

This study employed an interpretive descriptive approach [27] to provide a lens through which to examine processes within the constructed nature of health care. Appropriate approvals were obtained from the institutional review board and chief nursing executives before data were collected.

The study was conducted in two phases. The first phase involved field observation of the unit as a whole between August and December 2012. Observations from Phase 1 informed selection of potential participants for shadowing during Phase 2 completed February 2013 through July 2013.

3.2 Setting

The setting for this study was a 25-bed medical oncology unit in a 50-bed cancer specialty hospital - part of a tertiary academic medical center in the Western United States. This unit served a complex patient population with diagnoses including both solid tumors and blood-based cancers. Focusing on a single unit allowed the researchers to develop a deep understanding of the processes surrounding the production and use of nurses' paper brains without the need to understand cultural contexts across multiple units. The medical oncology unit employed approximately 35 nurses and used internal float nurses. An accurate number of float nurses was not available. The site hospital used a vendor EHR with available functionality including computerized provider order entry (CPOE), nursing documentation, physician documentation, an electronic medication administration record, and results review. A patient summary for handoff, called the Nursing Summary Report (NSR), was available as part of the EHR (▶Figure 1), and could be printed for use as a paper brain. The medical oncology unit implemented bar code medication administration between Phase 1 and Phase 2 of the study. Nurses did not use mobile devices such as smartphones or tablets as part of practice.

3.3 Sample

Criteria for selecting nurses for shadowed observations included representing the three different paper brain styles being used on the unit (hand-written free-form, preprinted skeletons, and the NSR) as well as nurse experience levels. All nurses approached for this phase of the study agreed to participate. Beginning with the second shadowed participant, data were evaluated for saturation [28]. Data saturation occurred after the thirteenth participant when no new codes were introduced during open coding and analysis did not raise new avenues of investigation.

3.4 Procedure

In Phase 1, observations began at least 30 minutes prior to a scheduled shift and ended at least one hour after the shift finished. Observations from this period were recorded in detailed field notes including thoughts and impressions of observed events and ideas to pursue as research continued. A total of 73 hours of general field observations were completed.

Phase 2 consisted of 129 hours of shadowed observations across the thirteenth nurses. The lead researcher (JB) collected detailed field notes during the shadowed shift. Immediately following this shift, the lead researcher interviewed the participant about their paper brain's structure, use, and development using a semi-structured technique. The interview guide appears in ▶Table 1. A professional transcription service transcribed audio recordings of interviews verbatim. Digital scans of nurses' paper brains were made at four time points during the nursing shift:

1. immediately before participants received handoff,
2. immediately after participants received handoff and indicated they were ready to begin patient care,
3. immediately before giving handoff to the following shift of nurses, and
4. immediately after the participant completed giving handoff at the end of their shift.

These time points occur at natural breaks in the nursing shift, minimizing the potential to disrupt workflow and impede naturalistic observation. Collecting paper brains at multiple time points allowed examination of the original content and structure, changes made to during the shift, and any additional changes made while giving handoff to the next shift.

3.5 Analysis

All data were imported into Atlas.ti [29] for storage and coding. Analytic memo writing began with initial participant and continued throughout data collection and analysis. Analytic memos provide a place throughout the study to generate ideas, explore thoughts and interpretations, and evaluate and reflect upon the activities of the study. The lead researcher used initial coding as described by Saldaña [30] to evaluate interviews, field notes, and analytic memos line-by-line, with a preference for *in vivo* and process codes whenever possible. Categories emerged from focused coding [30] of the results of the initial coding process and the data as a whole. Then these codes and categories were further developed into concepts. Creditability and fittingness through triangulation of data from observations and interviews and member checking with both nurses on the study unit and nurses working in other medical units in the same healthcare system [31, 32].

4. Results

4.1 Description of the Sample

All thirteen shadowed participants were staff nurses on the medical oncology unit at a cancer specialty hospital. The sample's median length of nursing experience was 4.5 years, ranging from seven months to 34 years. Nurses' experience on the oncology unit ranged from six months to 34 years, with a median of four years. The majority of nurses held Bachelors degrees, although two nurses had Associate degrees and one had a Masters degree. All but one nurse were female. Pseudonyms are used throughout the results to protect the privacy of nurse participants.

4.2 Life Cycle of a Paper Brain

Nurses' paper brains are deemed by nurses to be personal, dynamic objects. As a clinical instructor described, "[Paper brains] are like living things. They aren't just pieces of paper with information on it." Indeed, nurses' paper brains go through a life cycle during each shift, and an individual design can evolve over the course of a nurse's career. These two processes, or "hidden lives," are described below.

The term life cycle is defined as the series of changes in a biological organism, including birth, middle age, reproduction, and death of a living entity. Nurses' paper brains, go through a similar series of phases. Birth is analogous to the creation of a new paper brain at the beginning of the shift; middle age is the application of the paper brain during the shift; death occurs with the destruction of a paper brain when it is deemed no longer useful. Reproduction is the transfer of information by the nurse from an old paper brain to a new one. A model of the life cycle of nurses' paper brains can be seen in ►Figure 1.

Creation occurs while a nurse prepares a paper brain for use during the upcoming shift. This process begins when a nurse arrives on a unit and obtains an initial version of their personal paper brain format. This may be a blank sheet of paper for a free-form paper brain, an empty preprinted template or "skeleton", or an EHR-generated Nursing Summary Report (NSR), depending on the nurse's preference. Information about the nurses' patients is gathered from multiple sources, synthesized, and transferred to the new paper brain. Nurses considered Creation complete when the paper brain contained enough information to begin patient care. Rarely did this occur immediately after report was finished. Nurses would continue to review patient charts after the previous nurse(s) had left for the day. Nurses would try to finish the process of creation before moving on to patient care; however, this was not always possible. The nurse leaving shift or the charge nurse would try to take care of any immediate patient needs while creation was in process. This allowed the oncoming nurse to finish creating the paper brain before moving on to patient care. If the nurse leaving shift or the charge nurse were unable to provide this support, nurses paused Creation to attend to patients' needs before finishing the process.

The next phase in a paper brain's life cycle is Application. This is the process of using a paper brain for cognitive support during a shift and begins when a nurse starts actively caring for patients. The Application phase ends when the nurse determines the paper brain is no longer needed. This end point varies among nurses, ranging from immediately following giving report at the end of a shift, to days or weeks following the shift. Nurses, especially those who favored a free-form or skeleton paper brain, reported storing their paper brains for future reference. The process of synthesizing patient information into a coherent whole is time consuming, and nurses used old paper brains beyond the primary shift so information previously synthesized, especially prior medical history, psychosocial concerns, and patient preferences, could be reused on subsequent shifts. The process of transferring information from an old paper brain to a new one during creation is analogous to reproduction in the biological life cycle. Nurses were more likely to keep a paper brain if they were scheduled to work the next several days in a row as they would likely be assigned to the same patients on future shifts.

When a paper brain is deemed no longer useful, it is destroyed during the final phase in a paper brain's life cycle: Destruction. Destruction can occur immediately following a shift or significantly later. For nurses using the NSR, destruction occurred immediately following a shift. These nurses would place their paper brains in a locked box used to store sensitive documents for shredding as they left the unit at the end of their shift. Nurses who stored old paper brains in their lockers reported destroying them either after the last shift in a series of consecutive shifts, or in batches periodically when they cleaned out their locker. Paper brains were most often destroyed by the person who owns them. However, it was acceptable for others to destroy another's paper brain if abandoned by its owner.

4.3 Evolution of a Paper Brain

Just as nurses' paper brains exhibit life cycles over individual shifts, they also undergo processes similar to evolution in biological organisms. Evolution is the process living organisms go through to develop and diversify into different species. Evolution in a paper brain is caused by a change in the nurse's environment that reshapes their cognitive needs. If a paper brain is not able to provide cognitive support in the new environment, it is modified into (adaptation), or abandoned for (extinction), a different format that will provide the necessary support. With each new artifact life cycle, a nurse may either abandon or modify the paper brain until a new design solidifies that is "good enough" for the nurse's cognitive needs. Three types of change events that caused evolution for the nurses in this study are described below.

4.3.1 A nurse's first paper brain

Evolution begins with a nurse's first paper brain. For ten of the nurses in this study, their first paper brain was given to them when they started clinical practica in nursing school. None of the nurses interviewed received didactic training on how to create a paper brain. Nurses gained knowledge of how to make and use paper brains during clinical experience as a student or on the first job after graduation. Students frequently used the same paper brain format as their preceptor, using a new design with each different preceptor encountered, until a format "clicked with them." This final format would then be tweaked to address any design aspects that did not work for them individually. Font, location or groupings of data, and spacing were examples of modified aspects. Every nurse in the study expressed a willingness to share their personal design with other nurses and students.

As Lucy who used three different paper brain formats during field observations explained, "I've only been here...almost a year. I've gone through several different report sheets, like [paper] brains, to find out what works best for me. I did this one off of [Olivia]. But there's things that I still feel like I need to change." Comparison of ►Figure 2 and ►Figure 3 demonstrate the changes Lucy made to Olivia's skeleton to make it her own.

Preceptors guided students by describing what information was important to include in a paper brain, but stressed that the format had to work for the individual. During one field observation, a nurse preceptor explained to a student that the specific format of her paper brain did not matter, as long as the student was able to find needed information. As she explained this, the preceptor made a gesture moving her open hands from her temples to the page, as if she was lifting something out of her head and transferring it to the page. The preceptor offered the student a copy of her paper brain to use for the shift, but this student declined because she had a format she had been using for over a semester provided by her previous clinical instructor.

Two of the nurses spoke of "just figuring out" how to make their first paper brain. Both discussed having a feeling of being lost or overwhelmed on their first day. Zoe mentioned, "I just looked over other people's shoulders and saw how they [organized their paper brain] and took a little bit from here, little bit from there, and just developed it myself." Gretchen explained that her paper brain is an abridged form of the reports she had to write in nursing school for her clinical experience. The report was around 12 pages long - each page covering a different clinical topic. Each section of her paper brain corresponds with a page in the student report. She said that if the instructor wanted to know specific information, it was probably important to know, so she writes it down on her paper brain.

4.3.2 A change in the system

System changes – a change in focus from team to individual nursing, the implementation of a new EHR, or a move to bedside handoff, for example - can trigger the evolution of a nurse's paper brain.

When a system change occurs, cognitive needs change. Thus aspects of a cognitive artifact would change to provide support for those needs. Minor adjustments to the previous paper brain may be enough for the nurse to adapt to the new situation, or the previous paper brain may need to be abandoned completely. Zoe discussed how her paper brain changed when the hospital she was working for moved from a team-based approach to an individual approach to nursing:

> When I used to do team leading, it was on lined paper, not on white paper. And I would actually make lines going up and down the paper to create different areas where I would keep track of intake and output and then separate out where the IV information went It was a little more structured.

For Zoe, the evolution of her paper brain was not a difficult process. In contrast, Mary was in the process of moving from a free-form format that she had been using for several years to the administration-supported NSR at the time of her observation. For this nurse, the transition was not going well. Mary explained when she was floating to other units in the hospital, nurses on those units would consistently use the NSR. She said, "I'm trying to use this [NSR] and maybe get back in touch with what the administration thinks is a 'good nurse.'" However, Mary explained the NSR wasn't meeting her needs, "If all I do is use what actually appears in the [NSR], even if I highlighted them, most of what I need to get done that ensures that my patient gets a relatively safe experience will never happen." Within two weeks of her interview, Mary had abandoned the NSR for her free-form brain.

4.3.3 A new job

Sometimes the change that triggers evolution of a paper brain is a move to a new environment. Nurses who had come to this medical oncology unit from another hospital or type of unit described only needing to update their paper brains from their previous jobs to include information specific for medical oncology patients. Violet now writes down information related to chemotherapy, such as protocol, cycle number, and treatment day, in a space on her paper brain originally designated for diagnosis when she worked on a different unit.

Felix describes his unique readiness to adopt a new format when hired on a unit, "[Another hospital where I worked before] gave me one, and this one was given to me when I started here. I don't know. It's all based on what more experienced nurses have given me." His openness to new designs may be related to changing jobs, in that the change in environment leads to a dramatic change in workflow, making the nurse more open to a new system. Or, this openness may be an indicator of his relatively little experience as a nurse as was seen in Lucy, a nurse with less than a year experience. She expressed a similar openness to different formats, "I have absolutely no emotional connection to this piece of paper [chuckles]...If someone showed me something better, I would drop this thing in a heartbeat." However, Lucy was quick to qualify adding, "But again, I'm still learning what's best for me. Maybe 20 years from now, I'll be like, 'Don't you talk about my brain!'" This was in contrast to more experienced nurses who commented, "Don't take my paper brain away. I'll have to retire."

4.4 It's Good Enough: Stabilization After Change

After any process of paper brain evolution, the design eventually stabilized into a format that was considered "good enough." Olivia explained, "There's things I would change about it. This isn't perfect, but it's good enough. It works for me." Stabilization was most apparent in the skeleton format. All but one of the nurses using a skeleton format expressed a similar sentiment. Examples of desired changes included making the space designated for medical history and assessment larger, deleting an area they no longer used, and adding or removing labels. Electronic copies of blank skeletons, if they existed, were stored on home computers, not at the hospital, and were less of a priority once arriving home. Felix explained, "I wish I was motivated enough to go home and make [changes to my paper brain]. Usually I want to eat dinner and go to bed." Olivia mentioned that her template was created in a defunct version of Microsoft Office, so she was unable to edit it. Felix and Gretchen had only paper-based versions of their skeletons and would have to re-create it in electronic format to make any changes. This was seen as an unnecessary burden since their paper brains were viewed as "good enough."

For people who used a free-form paper brain, there was less of a barrier for change. For example, Mary explained that she had added a box around IV access information "so that it would pop out at [her] more," because she wanted to be able to see that information more quickly. However, at least one free-form paper brain showed signs of stabilization. ▶Figure 4 shows labels for intakes and outputs to be recorded, but these items of data were actually jotted down elsewhere on the page. Though they were no longer used, the brain's owner continued to write these labels for every patient.

Nurses using the NSR exhibited stabilization differently because the design was fixed within the EHR. If a nurse determined the NSR was not "good enough," it was abandoned for another style, as shown by Mary's return to her free-form brain after attempting to switch to the NSR. For nurses who used the NSR handwritten notes, highlights and annotations were used to achieve "good enough." Though each predefined section of the NSR would print in roughly the same area, certain sections-- particularly orders and labs – could vary in size patient to patient. Data could be truncated and specific orders could be in different locations within the section across patients (▶Figure 5 and ▶Figure 6). In ▶Figure 5, the order for diet is printed from the EHR midway down the right-hand column of orders. In ▶Figure 6, the diet order is not printed at all. For Kiera, stabilization manifested through always rewriting the diet order at the top middle of the page (▶Figure 5). Also seen in ▶Figure 5 and ▶Figure 6, the amount of free space for note-taking varied across patients. This required nurses who used the NSR to be more flexible about where they wrote additional information, and how much space they needed to do so.

5. Discussion

The results of this study demonstrate the dynamic, living nature of nurses' paper brains. Paper brains display a life cycle with four phases: Creation, Application, Reproduction, and Destruction. The length of this life cycle was tied to the nurses' preferred brain type, work schedule, and the patient's disease trajectory. The length between the end of a nurse's shift and the actual destruction of a paper brain tended to be longer for free-form and skeleton brains, and when nurses were scheduled to work multiple shifts in a row. The likelihood of seeing patients again and the need to know a patient's history – both related to the lengthy disease trajectories for oncology patients – were nearly always cited as reasons for the period of time before destruction. Paper brains also exhibit evolution across the career of a nurse. Evolutionary changes occur in response to changes in the nursing environment such as new employment or new workflow. These two processes have been neglected in the study of nurses' cognitive artifacts and thus represent the "hidden lives" of paper brains.

The previous focus by many researchers on paper brains as a means to standardize handoff communication is problematic [12–20, 33]. Inter-shift handoff occurs during the creation phase and again toward the end of the application phase. Focusing on paper brains' use solely at shift change itself ignores the cognitive support functions paper brains serve during the rest of the application phase and the reproduction phase of the life cycle.

Nurses' paper brains exhibit the six minimum traits of a cognitive artifact in a distributed cognition system as put forth by Jones and Nemeth [34]: accuracy, efficiency, reliability, informativeness, clarity, and malleability. Current attempts at electronic tools may fail to be incorporated into nursing practice because they fall short of these six required traits. Results from this study demonstrate electronic tools are lacking in efficiency and reliability to support cognitive needs during the Application and Reproduction phases of the life cycle and malleability of design to address changes in cognitive work.

During the application phase, synthesized information is a key way nurses 'know their patients' [35–37]. Knowing the patient has been described previously and is believed by nursing scholars to be at the heart of quality patient care [38–40]. Kelley et al. [35] demonstrated that nurses' report sheets (i.e., paper brains) are viewed by nurses as the most valuable information source for knowing the patient, and that information saved in the EHR as "nurse documentation" was not viewed as important as initially hypothesized. The results of the current study, taken with those of Kelley et al., indicate nursing knowledge is not sufficiently captured in current EHR documentation in general.

Nurses' paper brains evidence a need for nurses to further process and integrate medical information from the EHR. The work of abstracting different information from multiple sources is cognitively demanding and the reproduction phase of the paper brain life cycle helps to alleviate this demand by storing the information in synthesized form. Future designs of digital brains will need to either store the nurse-synthesized form within the EHR, or be able to construct it from the information in the medical record through natural language processing (NLP) or the use of a standard language. Work by Forbes, Surdeanu, Jansen, and Carrington [41] regarding clinical events gives a promising example of how NLP can be used to gather information from the EHR into a coherent narrative with clinical significance.

Individual cognitive needs may not always be congruent with group needs, thus a 'one-size-fits-all' approach to design for an electronic brain is not recommended. As seen in the evolution of Lucy's paper brain, specific formats "click" with individuals over other formats. A standardized tool that allows information pulled from the EHR, with flexibility in the display and organization of information, may allow nurses to have an individualized electronic brain that provides maximum cognitive support while still maintaining the Joint Commission's goal of standardized communication.

Lastly, a digital tool must allow individual nurses to change or personalize overall display design to accommodate differences in cognitive work or changes in cognitive work over time. Standardized tools, electronic or paper-based, will not provide cognitive support in all circumstances. Content and design of successful tools need to be tailored to context characteristics (i.e., this patient, this nurse, this unit, etc.) [5]. And, as cognitive needs change, the support provided by a non-adaptable cognitive artifact may diminish. Therefore, periodic evaluations of a standardized form - digital or paper-based - are necessary to determine if nurses' cognitive needs are being met, especially following policy changes affecting nursing workflow. Finding a balance between standardization and malleability by developing digital display designs consisting of standardized modules of related information placed according to preferences of individual nurses is a potential solution. As cognitive needs change, nurses may add or remove particular modules. Similar displays have been tested successfully with physicians as part of an EHR [42].

Even in the presence of a well-designed, personalized and malleable digital patient summary, the need for a paper brain may not be eliminated. Previous work has described the importance of handwriting for nurses in the generation of their paper brains [6, 43]. Nurses in these studies expressed how handwriting supported encoding of information and improved recall – a finding supported by research in human factors and education [44, 45]. Nurses' cognitive artifacts are reported to be spaces used to store information not intended to be included in the EHR such as reminders to call a patient's family or patient preferences [1, 6, 43].

No study is without its limitations. As with any study utilizing a qualitative approach, findings may not hold beyond this medical oncology unit. Shadowing a different set of nurses in a different setting might have yielded different findings. Additionally, participants reported descriptions of points when paper brains were initially created or adapted and duration paper brains were stored before destruction. However, observations and member checking with nurses on this and other acute care units did not contradict participants' reports.

Further research is needed to determine if the patterns of paper brain life cycles and evolutions hold across other types of units, especially with respect to patient trajectory. Future work is needed to explore different styles of paper brains and what makes a style "click" with a particular nurse. Is preference of style related to nurse characteristics like length of experience, age, or gender? Additionally, further examination of the concept of "good enough" in the evolution of paper brains should be explored. What are the conditions that move a paper brain from being "good enough" to requiring adaptation? More work is needed to examine how quickly a brain becomes solidified and the characteristics of a system that influence this process. Research in these areas will lead to better designs for future cognitive support tools by illuminating boundaries of necessary efficiency, reliability, and malleability.

6. Conclusion

The results of this study illuminate an aspect of cognitive artifacts in healthcare previously neglected by informatics. Nurses' paper brains exhibit changes over a life cycle during each shift, providing cognitive support beyond the context of handoff. As nurses' cognitive needs change with changes in workflow and work environment, paper brains evolve over the course of a nurse's career. As the study of cognitive artifacts such as handoff tools and even EHRs develops, consideration of the "hidden lives" of these objects beyond handoff is advised. By simply mimicking paper-based tools on an electronic screen, functions crucial to the practice of healthcare may be lost. A snapshot tool at the beginning of the shift also belies the needs of nurses during a whole shift. If these hidden lives are ignored during the needs analysis phase of technology development research, then electronic tools may be lacking critical functionality.

Clinical Relevance Statement

Nurses' paper brains are an important source of cognitive support in nursing practice, especially in acute care settings. Changes to their design and format implemented without fully appreciating their life cycle and evolution may have unintended consequences to nursing workflow and/or patient safety. Hospital administrators need to be mindful of the complex nature of activities such as handoffs in healthcare when writing policy changes such as mandating the use of a standardized template for handoffs.

Conflicts of Interest

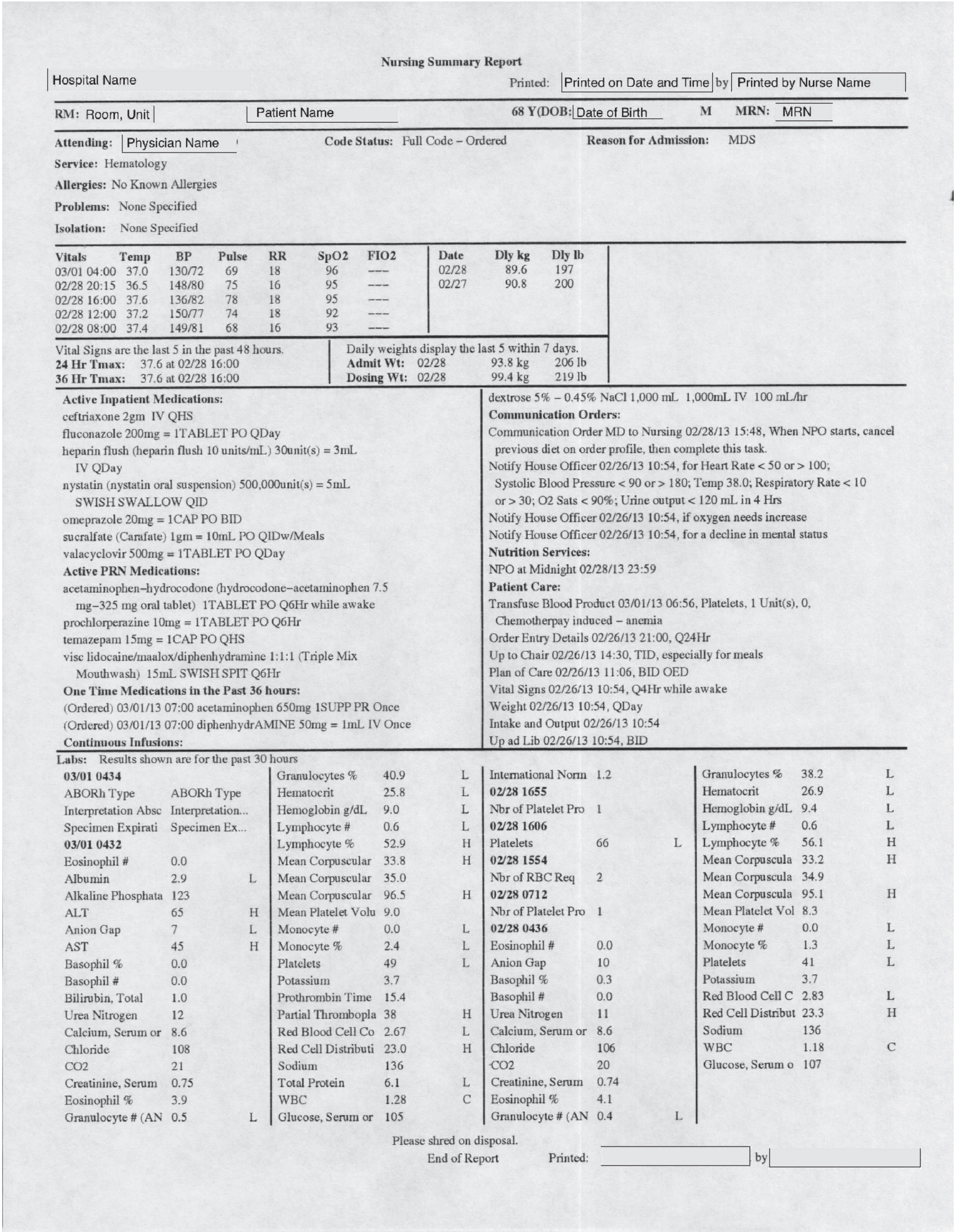
The authors declare that they have no conflicts of interest in the research.

Human Subject Research

Institutional Review Board (IRB) approval was obtained for all activities and informed consent was obtained from all shadowed participants. As part of informed consent, nurses gave permission for their paper brains to be reproduced for publication.

Acknowledgments

The authors would like to acknowledge Frank Drews, PhD and Jeanine Stefanucci, PhD for their contributions to preliminary study design for this research.
The authors especially want to thank the nurses on this oncology unit for their participation in this study and insights into their "brains."



Nursing Summary Report

Hospital Name

Printed: Printed on Date and Time by Printed by Nurse Name

RM: Room, Unit | Patient Name | 68 Y(DOB: Date of Birth | M | MRN: MRN

Attending: Physician Name | **Code Status:** Full Code – Ordered | **Reason for Admission:** MDS

Service: Hematology

Allergies: No Known Allergies

Problems: None Specified

Isolation: None Specified

Vitals	Temp	BP	Pulse	RR	SpO2	FIO2
03/01 04:00	37.0	130/72	69	18	96	---
02/28 20:15	36.5	148/80	75	16	95	---
02/28 16:00	37.6	136/82	78	18	95	---
02/28 12:00	37.2	150/77	74	18	92	---
02/28 08:00	37.4	149/81	68	16	93	---

Date	Dly kg	Dly lb
02/28	89.6	197
02/27	90.8	200

Vital Signs are the last 5 in the past 48 hours.
24 Hr Tmax: 37.6 at 02/28 16:00
36 Hr Tmax: 37.6 at 02/28 16:00

Daily weights display the last 5 within 7 days.
Admit Wt: 02/28 93.8 kg 206 lb
Dosing Wt: 02/28 99.4 kg 219 lb

Active Inpatient Medications:
ceftriaxone 2gm IV QHS
fluconazole 200mg = 1TABLET PO QDay
heparin flush (heparin flush 10 units/mL) 30unit(s) = 3mL IV QDay
nystatin (nystatin oral suspension) 500,000unit(s) = 5mL SWISH SWALLOW QID
omeprazole 20mg = 1CAP PO BID
sucralfate (Carafate) 1gm = 10mL PO QIDw/Meals
valacyclovir 500mg = 1TABLET PO QDay

Active PRN Medications:
acetaminophen–hydrocodone (hydrocodone–acetaminophen 7.5 mg–325 mg oral tablet) 1TABLET PO Q6Hr while awake
prochlorperazine 10mg = 1TABLET PO Q6Hr
temazepam 15mg = 1CAP PO QHS
visc lidocaine/maalox/diphenhydramine 1:1:1 (Triple Mix Mouthwash) 15mL SWISH SPIT Q6Hr

One Time Medications in the Past 36 hours:
(Ordered) 03/01/13 07:00 acetaminophen 650mg 1SUPP PR Once
(Ordered) 03/01/13 07:00 diphenhydrAMINE 50mg = 1mL IV Once

Continuous Infusions:
dextrose 5% – 0.45% NaCl 1,000 mL 1,000mL IV 100 mL/hr

Communication Orders:
Communication Order MD to Nursing 02/28/13 15:48, When NPO starts, cancel previous diet on order profile, then complete this task.
Notify House Officer 02/26/13 10:54, for Heart Rate < 50 or > 100; Systolic Blood Pressure < 90 or > 180; Temp 38.0; Respiratory Rate < 10 or > 30; O2 Sats < 90%; Urine output < 120 mL in 4 Hrs
Notify House Officer 02/26/13 10:54, if oxygen needs increase
Notify House Officer 02/26/13 10:54, for a decline in mental status

Nutrition Services:
NPO at Midnight 02/28/13 23:59

Patient Care:
Transfuse Blood Product 03/01/13 06:56, Platelets, 1 Unit(s), 0, Chemotherpay induced – anemia
Order Entry Details 02/26/13 21:00, Q24Hr
Up to Chair 02/26/13 14:30, TID, especially for meals
Plan of Care 02/26/13 11:06, BID OED
Vital Signs 02/26/13 10:54, Q4Hr while awake
Weight 02/26/13 10:54, QDay
Intake and Output 02/26/13 10:54
Up ad Lib 02/26/13 10:54, BID

Labs: Results shown are for the past 30 hours

03/01 0434		
ABORh Type	ABORh Type	
Interpretation Absc	Interpretation...	
Specimen Expirati	Specimen Ex...	
03/01 0432		
Eosinophil #	0.0	
Albumin	2.9	L
Alkaline Phosphata	123	
ALT	65	H
Anion Gap	7	L
AST	45	H
Basophil %	0.0	
Basophil #	0.0	
Bilirubin, Total	1.0	
Urea Nitrogen	12	
Calcium, Serum or	8.6	
Chloride	108	
CO2	21	
Creatinine, Serum	0.75	
Eosinophil %	3.9	
Granulocyte # (AN	0.5	L
Granulocytes %	40.9	L
Hematocrit	25.8	L
Hemoglobin g/dL	9.0	L
Lymphocyte #	0.6	L
Lymphocyte %	52.9	H
Mean Corpuscular	33.8	H
Mean Corpuscular	35.0	
Mean Corpuscular	96.5	H
Mean Platelet Volu	9.0	
Monocyte #	0.0	L
Monocyte %	2.4	L
Platelets	49	L
Potassium	3.7	
Prothrombin Time	15.4	
Partial Thrombopla	38	H
Red Blood Cell Co	2.67	L
Red Cell Distributi	23.0	H
Sodium	136	
Total Protein	6.1	L
WBC	1.28	C
Glucose, Serum or	105	
International Norm	1.2	
02/28 1655		
Nbr of Platelet Pro	1	
02/28 1606		
Platelets	66	L
02/28 1554		
Nbr of RBC Req	2	
02/28 0712		
Nbr of Platelet Pro	1	
02/28 0436		
Eosinophil #	0.0	
Anion Gap	10	
Basophil %	0.3	
Basophil #	0.0	
Urea Nitrogen	11	
Calcium, Serum or	8.6	
Chloride	106	
CO2	20	
Creatinine, Serum	0.74	
Eosinophil %	4.1	
Granulocyte # (AN	0.4	L
Granulocytes %	38.2	L
Hematocrit	26.9	L
Hemoglobin g/dL	9.4	L
Lymphocyte #	0.6	L
Lymphocyte %	56.1	H
Mean Corpuscula	33.2	H
Mean Corpuscula	34.9	
Mean Corpuscula	95.1	H
Mean Platelet Vol	8.3	
Monocyte #	0.0	L
Monocyte %	1.3	L
Platelets	41	L
Potassium	3.7	
Red Blood Cell C	2.83	L
Red Cell Distribut	23.3	H
Sodium	136	
WBC	1.18	C
Glucose, Serum o	107	

Please shred on disposal.
End of Report Printed: by

Fig. 1 **The Nursing Summary Report (NSR)**: a Patient Summary Designed for Nurses' Use During Handoff. (Permission was obtained from Huntsman Cancer Hospital to include in the manuscript.)

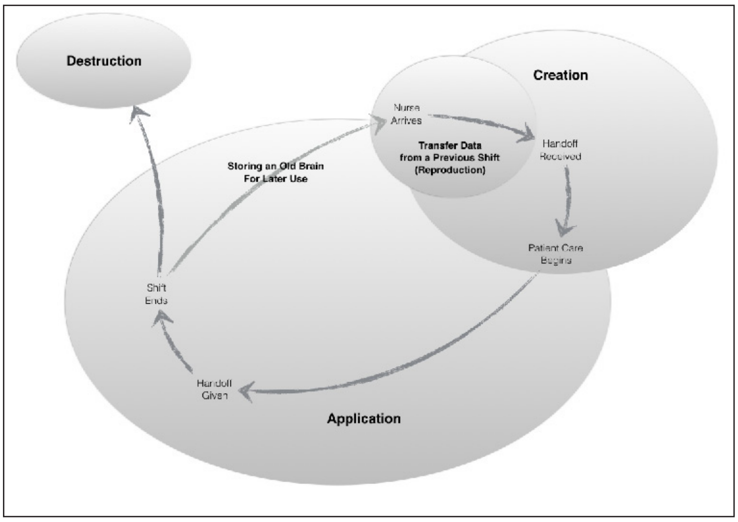


Fig. 2 The Life Cycle of a Nurse's Paper Brain

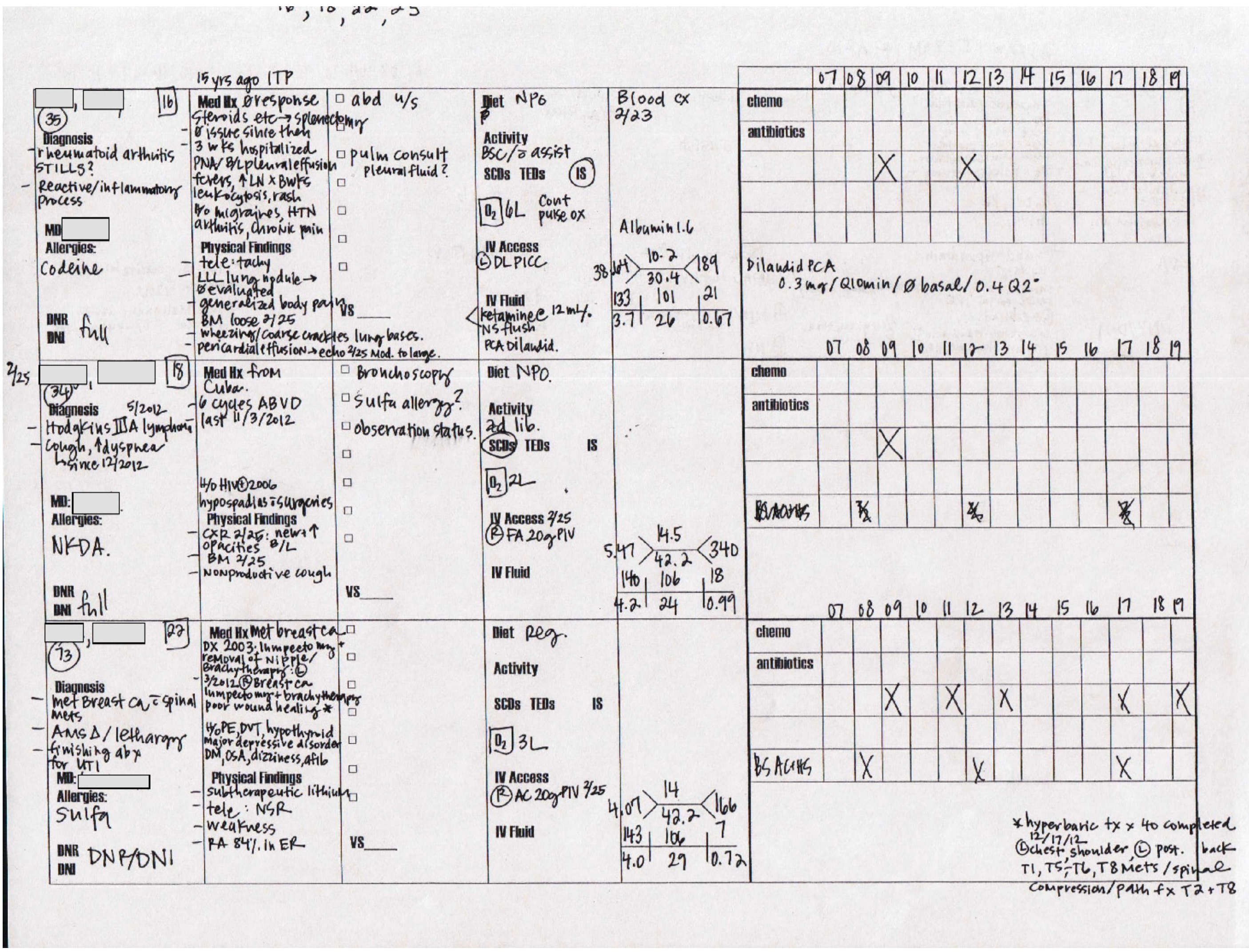


Fig. 3 Olivia's Paper Brain

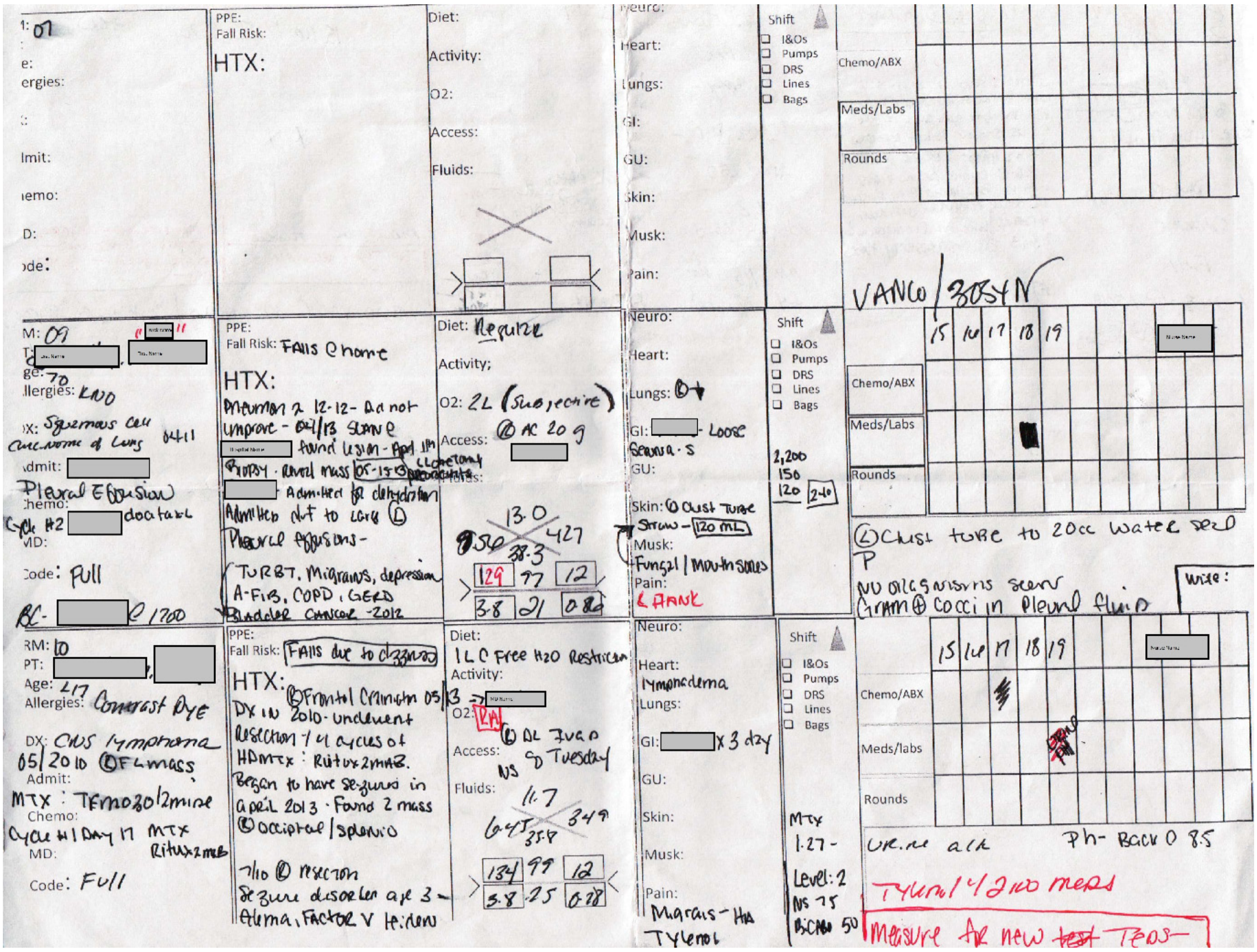


Fig. 4 Lucy's Paper Brain

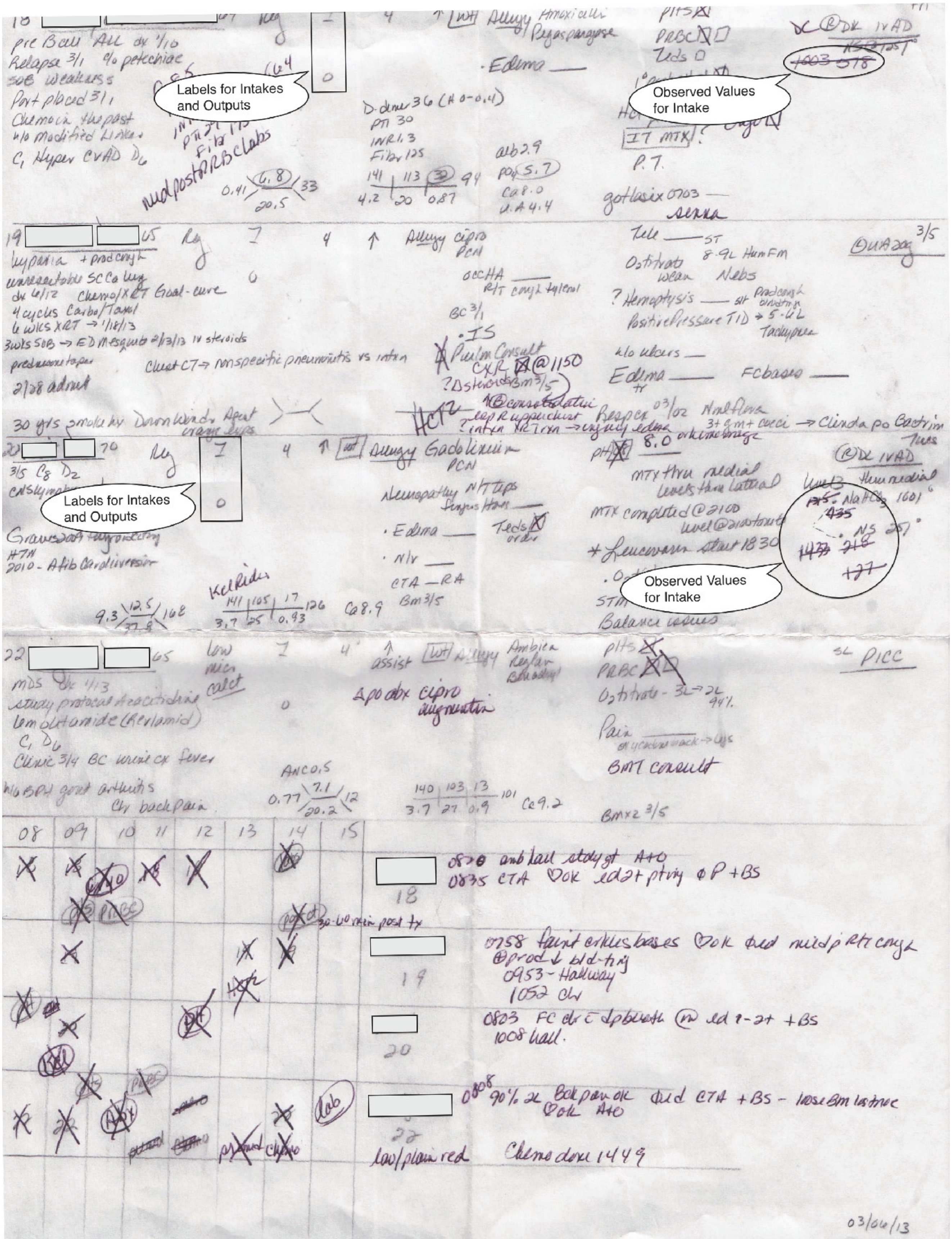
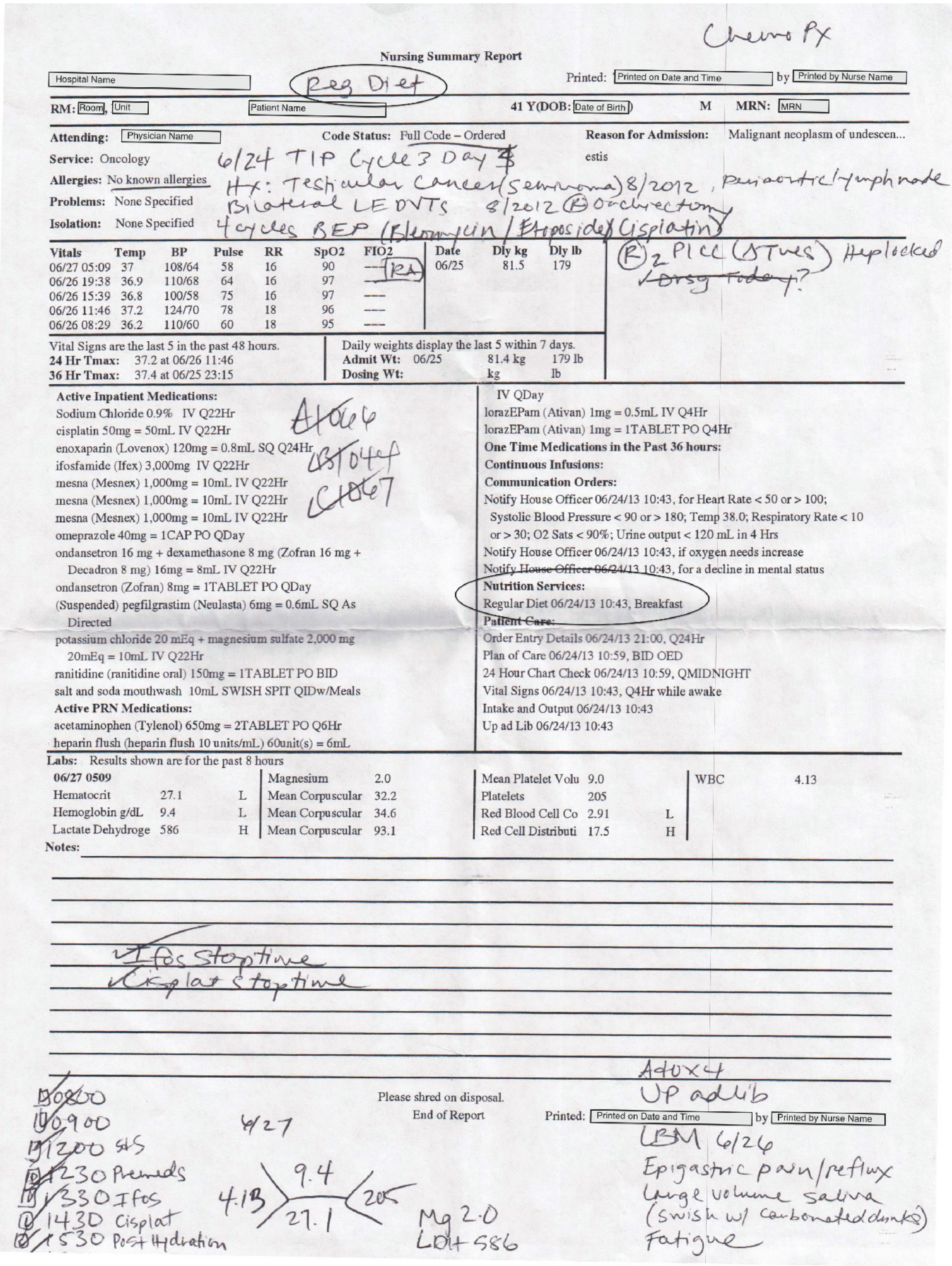


Fig. 5 Zoe's Paper Brain with Labels and Values of Intakes and Outputs Indicated



Chemo Px

Nursing Summary Report

Hospital Name | Reg Diet | Printed: Printed on Date and Time by Printed by Nurse Name

RM: Room, Unit | Patient Name | 41 Y(DOB: Date of Birth) | M | MRN: MRN

Attending: Physician Name | Code Status: Full Code – Ordered | Reason for Admission: Malignant neoplasm of undescen... estis

Service: Oncology — 6/24 TIP Cycle 3 Day 4

Allergies: No known allergies — Hx: Testicular Cancer (seminoma) 8/2012, Periaortic lymph node

Problems: None Specified — Bilateral LE DVTs 8/2012 (R) Orchiectomy

Isolation: None Specified — 4 cycles BEP (Bleomycin / Etoposide / Cisplatin)

Vitals	Temp	BP	Pulse	RR	SpO2	FIO2
06/27 05:09	37	108/64	58	16	90	--- (RA)
06/26 19:38	36.9	110/68	64	16	97	---
06/26 15:39	36.8	100/58	75	16	97	---
06/26 11:46	37.2	124/70	78	18	96	---
06/26 08:29	36.2	110/60	60	18	95	---

Date	Dly kg	Dly lb
06/25	81.5	179

(R) 2 PICC (2 Tubes) Heplocked — ~~D/Drsg Today?~~

Vital Signs are the last 5 in the past 48 hours.
24 Hr Tmax: 37.2 at 06/26 11:46
36 Hr Tmax: 37.4 at 06/25 23:15

Daily weights display the last 5 within 7 days.
Admit Wt: 06/25 81.4 kg 179 lb
Dosing Wt: kg lb

Active Inpatient Medications:
Sodium Chloride 0.9% IV Q22Hr — A1046
cisplatin 50mg = 50mL IV Q22Hr
enoxaparin (Lovenox) 120mg = 0.8mL SQ Q24Hr — B1044
ifosfamide (Ifex) 3,000mg IV Q22Hr
mesna (Mesnex) 1,000mg = 10mL IV Q22Hr — C1067
mesna (Mesnex) 1,000mg = 10mL IV Q22Hr
mesna (Mesnex) 1,000mg = 10mL IV Q22Hr
omeprazole 40mg = 1CAP PO QDay
ondansetron 16 mg + dexamethasone 8 mg (Zofran 16 mg + Decadron 8 mg) 16mg = 8mL IV Q22Hr
ondansetron (Zofran) 8mg = 1TABLET PO QDay
(Suspended) pegfilgrastim (Neulasta) 6mg = 0.6mL SQ As Directed
potassium chloride 20 mEq + magnesium sulfate 2,000 mg 20mEq = 10mL IV Q22Hr
ranitidine (ranitidine oral) 150mg = 1TABLET PO BID
salt and soda mouthwash 10mL SWISH SPIT QIDw/Meals
Active PRN Medications:
acetaminophen (Tylenol) 650mg = 2TABLET PO Q6Hr
heparin flush (heparin flush 10 units/mL) 60unit(s) = 6mL IV QDay
lorazEPam (Ativan) 1mg = 0.5mL IV Q4Hr
lorazEPam (Ativan) 1mg = 1TABLET PO Q4Hr
One Time Medications in the Past 36 hours:
Continuous Infusions:
Communication Orders:
Notify House Officer 06/24/13 10:43, for Heart Rate < 50 or > 100; Systolic Blood Pressure < 90 or > 180; Temp 38.0; Respiratory Rate < 10 or > 30; O2 Sats < 90%; Urine output < 120 mL in 4 Hrs
Notify House Officer 06/24/13 10:43, if oxygen needs increase
Notify House Officer 06/24/13 10:43, for a decline in mental status
Nutrition Services:
Regular Diet 06/24/13 10:43, Breakfast
Patient Care:
Order Entry Details 06/24/13 21:00, Q24Hr
Plan of Care 06/24/13 10:59, BID OED
24 Hour Chart Check 06/24/13 10:59, QMIDNIGHT
Vital Signs 06/24/13 10:43, Q4Hr while awake
Intake and Output 06/24/13 10:43
Up ad Lib 06/24/13 10:43

Labs: Results shown are for the past 8 hours

06/27 0509										
Hematocrit	27.1	L	Magnesium	2.0	Mean Platelet Volu	9.0		WBC	4.13
Hemoglobin g/dL	9.4	L	Mean Corpuscular	32.2	Platelets	205			
Lactate Dehydroge	586	H	Mean Corpuscular	34.6	Red Blood Cell Co	2.91	L		
			Mean Corpuscular	93.1	Red Cell Distributi	17.5	H		

Notes:
✓ Ifos Stop time
✓ Cisplat Stop time

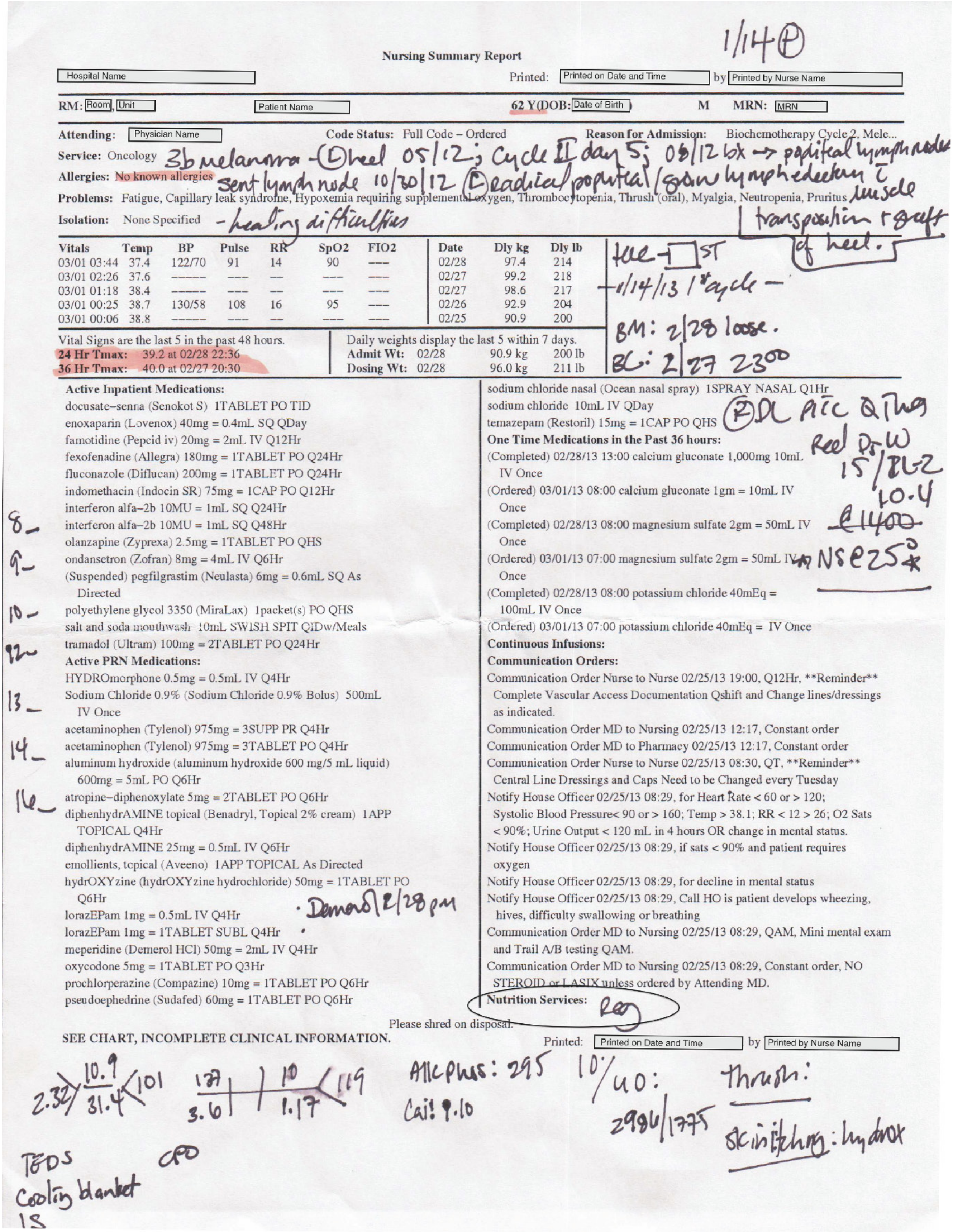
0800
0900
1200 S+S
1230 Premeds
1330 Ifos
1430 Cisplat
1530 Post Hydration

6/27
4.13 — 9.4 / 27.1 — 205
Mg 2.0
LDH 586

A10x4
UP ad lib
LBM 6/26
Epigastric pain/reflux
Large volume saliva (swish w/ carbonated drinks)
Fatigue

Please shred on disposal.
End of Report
Printed: Printed on Date and Time by Printed by Nurse Name

Fig. 6 Kiera's Paper Brain with Diet Order Indicated with an Oval



Nursing Summary Report

Hospital Name — Printed: Printed on Date and Time by Printed by Nurse Name

RM: Room, Unit — Patient Name — 62 Y DOB: Date of Birth — M — MRN: MRN

Attending: Physician Name — **Code Status:** Full Code – Ordered — **Reason for Admission:** Biochemotherapy Cycle 2, Mele...

Service: Oncology

Allergies: No known allergies

Problems: Fatigue, Capillary leak syndrome, Hypoxemia requiring supplemental oxygen, Thrombocytopenia, Thrush (oral), Myalgia, Neutropenia, Pruritus

Isolation: None Specified

Vitals	Temp	BP	Pulse	RR	SpO2	FIO2
03/01 03:44	37.4	122/70	91	14	90	---
03/01 02:26	37.6	------	---	--	---	---
03/01 01:18	38.4	------	---	--	---	---
03/01 00:25	38.7	130/58	108	16	95	---
03/01 00:06	38.8	------	---	--	---	---

Date	Dly kg	Dly lb
02/28	97.4	214
02/27	99.2	218
02/27	98.6	217
02/26	92.9	204
02/25	90.9	200

Vital Signs are the last 5 in the past 48 hours.
24 Hr Tmax: 39.2 at 02/28 22:36
36 Hr Tmax: 40.0 at 02/27 20:30

Daily weights display the last 5 within 7 days.
Admit Wt: 02/28 90.9 kg 200 lb
Dosing Wt: 02/28 96.0 kg 211 lb

Active Inpatient Medications:
docusate–senna (Senokot S) 1TABLET PO TID
enoxaparin (Lovenox) 40mg = 0.4mL SQ QDay
famotidine (Pepcid iv) 20mg = 2mL IV Q12Hr
fexofenadine (Allegra) 180mg = 1TABLET PO Q24Hr
fluconazole (Diflucan) 200mg = 1TABLET PO Q24Hr
indomethacin (Indocin SR) 75mg = 1CAP PO Q12Hr
interferon alfa–2b 10MU = 1mL SQ Q24Hr
interferon alfa–2b 10MU = 1mL SQ Q48Hr
olanzapine (Zyprexa) 2.5mg = 1TABLET PO QHS
ondansetron (Zofran) 8mg = 4mL IV Q6Hr
(Suspended) pegfilgrastim (Neulasta) 6mg = 0.6mL SQ As Directed
polyethylene glycol 3350 (MiraLax) 1packet(s) PO QHS
salt and soda mouthwash 10mL SWISH SPIT QIDw/Meals
tramadol (Ultram) 100mg = 2TABLET PO Q24Hr

Active PRN Medications:
HYDROmorphone 0.5mg = 0.5mL IV Q4Hr
Sodium Chloride 0.9% (Sodium Chloride 0.9% Bolus) 500mL IV Once
acetaminophen (Tylenol) 975mg = 3SUPP PR Q4Hr
acetaminophen (Tylenol) 975mg = 3TABLET PO Q4Hr
aluminum hydroxide (aluminum hydroxide 600 mg/5 mL liquid) 600mg = 5mL PO Q6Hr
atropine–diphenoxylate 5mg = 2TABLET PO Q6Hr
diphenhydrAMINE topical (Benadryl, Topical 2% cream) 1APP TOPICAL Q4Hr
diphenhydrAMINE 25mg = 0.5mL IV Q6Hr
emollients, topical (Aveeno) 1APP TOPICAL As Directed
hydrOXYzine (hydrOXYzine hydrochloride) 50mg = 1TABLET PO Q6Hr
lorazEPam 1mg = 0.5mL IV Q4Hr
lorazEPam 1mg = 1TABLET SUBL Q4Hr
meperidine (Demerol HCl) 50mg = 2mL IV Q4Hr
oxycodone 5mg = 1TABLET PO Q3Hr
prochlorperazine (Compazine) 10mg = 1TABLET PO Q6Hr
pseudoephedrine (Sudafed) 60mg = 1TABLET PO Q6Hr

sodium chloride nasal (Ocean nasal spray) 1SPRAY NASAL Q1Hr
sodium chloride 10mL IV QDay
temazepam (Restoril) 15mg = 1CAP PO QHS

One Time Medications in the Past 36 hours:
(Completed) 02/28/13 13:00 calcium gluconate 1,000mg 10mL IV Once
(Ordered) 03/01/13 08:00 calcium gluconate 1gm = 10mL IV Once
(Completed) 02/28/13 08:00 magnesium sulfate 2gm = 50mL IV Once
(Ordered) 03/01/13 07:00 magnesium sulfate 2gm = 50mL IV Once
(Completed) 02/28/13 08:00 potassium chloride 40mEq = 100mL IV Once
(Ordered) 03/01/13 07:00 potassium chloride 40mEq = IV Once

Continuous Infusions:

Communication Orders:
Communication Order Nurse to Nurse 02/25/13 19:00, Q12Hr, **Reminder** Complete Vascular Access Documentation Qshift and Change lines/dressings as indicated.
Communication Order MD to Nursing 02/25/13 12:17, Constant order
Communication Order MD to Pharmacy 02/25/13 12:17, Constant order
Communication Order Nurse to Nurse 02/25/13 08:30, QT, **Reminder** Central Line Dressings and Caps Need to be Changed every Tuesday
Notify House Officer 02/25/13 08:29, for Heart Rate < 60 or > 120; Systolic Blood Pressure< 90 or > 160; Temp > 38.1; RR < 12 > 26; O2 Sats < 90%; Urine Output < 120 mL in 4 hours OR change in mental status.
Notify House Officer 02/25/13 08:29, if sats < 90% and patient requires oxygen
Notify House Officer 02/25/13 08:29, for decline in mental status
Notify House Officer 02/25/13 08:29, Call HO is patient develops wheezing, hives, difficulty swallowing or breathing
Communication Order MD to Nursing 02/25/13 08:29, QAM, Mini mental exam and Trail A/B testing QAM.
Communication Order MD to Nursing 02/25/13 08:29, Constant order, NO STEROID or LASIX unless ordered by Attending MD.

Nutrition Services: Reg

Please shred on disposal.

SEE CHART, INCOMPLETE CLINICAL INFORMATION.

Printed: Printed on Date and Time by Printed by Nurse Name

Fig. 7 Mary's Paper Brain with Diet Order Indicated with an Oval

Table 1 Interview Questions and Probes

1. Tell me about your paper (ask them what they call it). 2. Tell me about how you learned to make your paper brain [insert their term for paper brain if different]? 3. If you were to teach someone how to make a [paper brain], what would you tell them? 4. Tell me about how you use your [paper brain]?
Possible follow-up questions
1. Has your [paper brain] always been like this? Has it changed over time? When did it solidify into this format? 2. What kinds of things do you do with your [paper brain]? What happens if you lose it during the day? What happens if you find someone's [paper brain] lying around? 3. If a new policy was implemented that said you could no longer make or use [paper brain], how would that change your practice? 4. Do you ever see your [paper brain] being made electronic? With possible specific follow-up: a. What is it about your [paper brain] that makes an electronic version likely/unlikely? b. What would an electronic version have to be like (functions, information, physical characteristics) in order for you to use it?

References

1. Hardey M, Payne S, Coleman P. 'Scraps': hidden nursing information and its influence on the delivery of care. J Adv Nurs 2000; 32(1): 208–214.
2. Klee K, Latta L, Davis-Kirsch S, Pecchia M. Using continuous process improvement methodology to standardize nursing handoff communication. J Pediatr Nurs 2012; 27(2): 168–173.
3. Randell R, Wilson S, Woodward P, Galliers J. The ConStratO model of handover: a tool to support technology design and evaluation. Behav Inf Technol 2011; 30(4): 489–498.
4. Randell R, Woodward P, Wilson S, Galliers J. Public yet private: The status, durability and visibility of handover sheets. Proceedings of the 21st IEEE international symposium on computer-based medical systems (CBMS), IEEE; 2008: 500–502.
5. Staggers N, Clark L, Blaz JW, Kapsandoy S. Nurses' information management and use of electronic tools during acute care handoffs. West J Nurs Res 2012; 34(2): 153–173.
6. Staggers N, Clark L, Blaz JW, Kapsandoy S. Why patient summaries in electronic health records do not provide the cognitive support necessary for nurses' handoffs on medical and surgical units: Insights from interviews and observations. Health Informatics J 2011; 17(3): 209-223.
7. McLane S, Turley J, Esquivel A, Engebretson J, Smith K, Wood G, Zhang J. Concept analysis of cognitive artifacts. ANS Adv Nurs Sci 2010; 33(4): 352–362.
8. McLane S, Esquivel A, Turley J. Developing a taxonomy and an ontology of nurses' patient clinical summaries. Stud Health Technol Inform 2009; 146: 352–357.
9. Norman DA. Cognitive artifacts. In: Carroll J, editor. Designing interaction: psychology at the human-computer interface. New York: Cambridge University Press; 1991. p. 17–38. (Cambridge series on human-computer interaction 4).
10. Hutchins E. Cognition in the wild. Cambridge (MA): The MIT Press; 1995.
11. Hazlehurst B, Gorman P, McMullen C. Distributed cognition: an alternative model of cognition for medical informatics. Int J Med Inform 2008; 77(4): 226–234.
12. Alvarado K, Lee R, Christoffersen E, Fram N, Boblin S, Poole N, Lucas J, Forsyth S. Transfer of accountability: transforming shift handover to enhance patient safety. Healthc Q 2006; 9: 75–79.
13. Athwal P, Fields W, Wagnell E. Standardization of Change-of-Shift Report. J Nurs Care Qual. 2009;24(2):143–7.
14. Baldwin L, McGinnis C. A computer-generated shift report. Nurs Manage 1994; 25(9): 61–64.
15. Caruso E. The evolution of nurse-to-nurse bedside report on a medical-surgical cardiology unit. MEDSURG Nurs 2007; 16(1): 17–22.
16. Davies S, Priestly M. A reflective evaluation of patient handover practices. Nurs Stand 2006; 20(21): 49–52.
17. Mosher C, Bontomasi R. How to improve your shift report. Am J Nurs 1996; 96(8): 32–34.
18. Welsh C, Flanagan M, Ebright P. Barriers and facilitators to nursing handoffs: recommendations for redesign. Nurs Outlook 2010; 58(3): 148–154.
19. Collins SA, Stein DM, Vawdrey DK, Stetson PD, Bakken S. Content overlap in nurse and physician handoff artifacts and the potential role of electronic health records: a systematic review. J Biomed Inform 2011; 44(4): 704–712.
20. Wilson S, Galliers J, Fone J. Cognitive artifacts in support of medical shift handover: an in use, in situ evaluation. Int J Hum Comput Interact 2007; 22(1–2): 59–80.
21. Abraham J, Kannampallil T, Patel VL. A systematic review of the literature on the evaluation of handoff tools: implications for research and practice. J Am Med Inform Assoc 2014; 21(1): 154–162.
22. Joint Commission on Accreditation of Healthcare Organizations. Joint Commission announces 2006 national patient safety goals for ambulatory care and office-based surgery organizations 2005.
23. American Health Consultants, Inc. JCAHO to look closely at patient handoffs: communication lapses will be key focus. (Joint Commission on Accreditation of Health Care Organizations). HealthCare Benchmarks and Quality Improvement 2005; 12: 143–144.
24. Randell R, Wilson S, Woodward P, Galliers J. Beyond handover: supporting awareness for continuous coverage. Cogn Technol Work 2010; 12(4): 271–283.
25. Nielsen J. Usability engineering. Boston: AP Professional; 1993.
26. Shneiderman B, Plaisant C. Designing the user interface. 5th ed. Upper Saddle River (NJ): Addison-Wesley; 2010.
27. Thorne S. Interpretive Description. Walnut Creek (CA): Left Coast Press, Inc. 2008.
28. Sandelowski M. Sample size in qualitative research. Res Nurs Health 1995; 18(2): 179–183.
29. Muhr T. Atlas/Ti for Windows Version 6.1 1997.
30. Saldaña J. The coding manual for qualitative researchers. Los Angeles: Sage Publications Ltd; 2009.

31. Beck CT. Qualitative Research: the evaluation of its credibility, fittingness, and auditability. West J Nurs Res 1993; 15(2): 263–266.
32. Chiovitti RF, Piran N. Rigour and grounded theory research. J Adv Nurs 2003; 44(4): 427–435.
33. Wilson M. A template for safe and concise handovers. MEDSURG Nurs 2007; 16(3): 201–206.
34. Jones P, Nemeth C. Cognitive artifacts in complex work. Lectures Notes in Artificial Intelligence 2005; 3345 LNAI: 152–183.
35. Kelley T, Docherty S, Brandon D. Information needed to support knowing the patient. ANS Adv Nurs Sci 2013; 36(4): 351–363.
36. Leight SB. Starry night: using story to inform aesthetic knowing in women's health nursing. J Adv Nurs 2002; 37(1): 108–114.
37. Radwin LE. Knowing the patient: a process model for individualized interventions. Nurs Res 1995; 44(6): 364–370.
38. Bonis SA. Knowing in nursing: a concept analysis. J Adv Nurs 2009; 65(6): 1328–1341.
39. Bruni A, Gherardi S, Parolin L. Knowing in a system of fragmented knowledge. Mind Cult Activ 2007; 14(1): 83–102.
40. Paton B. Knowing within: practice wisdom of clinical nurse educators. J Nurs Educ 2007; 46(11): 488–495.
41. Forbes A, Surdeanu M, Jansen P, Carrington J. Transmitting narrative: an interactive shift-summarization tool for improving nurse communication. In: IEEE Workshop on Interactive Visual Text Analytics, Atlanta, Georgia, 2013.
42. Senathirajah Y, Bakken S. Architectural and usability considerations in the development of a Web 2.0-based EHR. Stud Health Technol Inform 2009; 143: 315–321.
43. McLane S, Turley JP. One Size Does Not Fit All: EHR Clinical Summary Design Requirements for Nurses. NI 2012: Proceedings of the 11th International Congress on Nursing Informatics 2012; 2012: 283.
44. Smoker TJ, Murphy CE, Rockwell AK. Comparing memory for handwriting versus typing. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2009; 53: 1744–1747.
45. Mangen A, Anda LG, Oxborough GH, Brønnick, K. Handwriting versus keyboard writing: effect on word recall. J Writ Res 2015; 7(2): 227–247.