

Exploring the Creation of Nurses' Informal Documentation and Use in Clinical Work

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2. Structured Abstract

Purpose: The purpose of this research was to develop a deep understanding of nurses' brains in the context of a medical oncology unit at a cancer hospital that is part of an academic health sciences center, and to derive successful strategies for the development of electronic tools based on this deep understanding. **Scope:** Nurses are well known to produce their own personalized objects, known as paper "brains," to organize information during a shift. Inter-shift handoffs have significant potential to create patient harm due to breakdowns in communication from information loss or misinterpretation. Nurses continued reliance on paper forms, despite availability of robust EHRs and electronic handoff tools, could be traced to insufficient understanding of the role the handoff tool or 'brains' play in nurses' clinical work. **Methods:** Thirteen nurses from a medical oncology unit in an intermountain west cancer specialty hospital were shadowed during an entire shift and interviewed following the shift. In addition, digital scans of the nurses' paper brains were obtained immediately prior to and after handoff at the beginning and end of the shift. A grounded theory approach was used to analyze these data. **Results:** Though a final substantive theory is not yet complete, initial findings suggest four major concepts: brains provide cognitive support, brains are a representation of nurse identity, brains represent the patient, and brains are living objects. **Key Words:** medical oncology nursing, cognitive artifacts, documentation, handoff, safety, communication, informatics

3. Purpose

Nurses are well known to produce their own personalized objects to organize information during a shift. (1-6) Previous research has characterized these objects as "handoff tools." (7-14) However, this characterization may be a limited view of the purposes these objects serve and the processes that lead to their construction. The term also assumes that these are purely functional objects, produced for the specific task of the inter-shift handoff, yet the collection or organization of patient information for handoffs accounts for only a portion of their use. Interestingly, nurses themselves do not refer to these objects as "handoff tools." Nurses have been known to call them "scraps," (1) "my paper," (1,5,6) and "brains." (5,6) The latter term indicates a deeper purpose for these objects than just handoffs, thus the term "brains" will be used to represent these objects in this report.

Previous research has described brains as private spaces that combine personal and professional knowledge. Brains are an informal documentation outside of the official healthcare record and have only recently been recognized as an integral part of nursing workflow. (1,4-6,15) Nurses have reported using their brains to synthesize information about patients and plan care for the upcoming shift. (1,5,6) Yet brains are more than just a place to store information and prioritize tasks. Hardey, et al. (1) claim that nurses' brains exist as a space to define and organize nursing knowledge. Because brains are designed as a personal and private space, they are a safe place to record information and reminders that might be inappropriate to include in the official medical record. (4-6) Though these studies were limited to the context of handoff, results hint at uses beyond this context that influence how nursing is practiced. Even so, research has yet to move in this direction. There is no research to date that describes the meaning brains have for nurses, the process of their construction, and the role brains play during an entire shift.

Standardizing free-form handoff tools has been suggested as a strategy to improve efficiency of giving report at the end of a shift. (16) This has 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 as cognitive artifacts. (15,17-19) However, in a recent study, researchers observed that nurses will continue to use personally created 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 brains throughout an entire shift as a quick reference for information pertinent to a shift, a to do list, and a place to synthesize data into a holistic representation of a patient. (1,2,4-6,18) It is possible that standardized handoff tools have not been more widely adopted because nurses' brains and their functions are not fully understood. Standardized tools designed to incorporate the range of purposes have greater potential to be adopted than those that do not. Therefore, an understanding of the production and meaning of brains for nurses is imperative because a standardized tool must support all needs of its users or it is doomed to be underutilized. (20,21)

The purpose of this research was to develop a deep understanding of nurses' brains in the context of a medical oncology unit at a cancer hospital that is part of an academic health sciences center. A grounded theory approach allowed for the development of a theory of nurses' brains, including the meanings ascribed to brains, how nurses produce their brains, and a deep knowledge of the functions brains serve for nurses in a medical oncology setting. Further, successful strategies for the development of electronic tools will be derived from the theory developed. This study was limited to a single unit to allow a deep understanding of brains, without having to tease out cultural differences across units. The medical oncology unit was selected because

the principal investigator (PI) has prior experience conducting research in this setting and nurses working in the unit demonstrated interest in participating in further research studies with the PI. In addition, patients admitted to the medical oncology unit tend to be complex, with co-morbidities beyond treatment for cancer. This complexity creates a setting rich with data, ideal for grounded theory.

Specific Aims:

1. To use a grounded theory approach to develop a deep understanding of nurses' brains, including the meanings ascribed to brains, how nurses produce their brains, the functions brains serve for nurses practicing in a medical oncology setting, and the content and structure found in brains.
2. To derive successful strategies for the development of an electronic brain that can be used as a handoff tool.

4. Scope

Inter-shift handoffs have significant potential to create patient harm due to breakdowns in communication from information loss or misinterpretation. (22) Inadequate handoffs are associated with sentinel events, critical incidents, errors, and near misses. (23-25) Nursing handoffs, also called handover, change of shift report, inter-shift report, and sign-out, occur during every shift change, every day of the year in every acute care unit nationwide. Inadequate handoffs have the potential to affect the safety of hospitalized patients every time critical information is transferred from one nurse to another.

Standardizing handoffs has been recommended to improve communication, with electronic tools as the primary recommendation by multiple authors. (3,4,17,18) In 2006, the Joint Commission made improving handoff communication one of their patient safety goals, suggesting that handoffs follow a standard format. (26) The increased availability of electronic health records (EHRs) affords a natural platform for computerized handoff tools. The EHR could easily be used to create a standardized handoff; however, there is a lack of accepted guidelines for the structure of handoffs and no consensus for the best possible tool or format exists. (27-31) An integrative review of handoff tools for the acute care setting by the applicant and sponsor showed that handoff tools come in a variety of formats with differing levels of content specificity and were nearly always printed out to be carried by the nurse during a shift. (32,33) Despite the widespread adoption of the EHR, little if any EHR integration was found on the 15 tools examined. In fact, nurses in these studies printed the electronic forms to use during handoff.

Nurses continued reliance on paper forms, despite availability of robust EHRs and electronic handoff tools, could be traced to insufficient understanding of the role the handoff tool or 'brains' play in nurses' clinical work. Handoff tools, particularly computerized handoff tools, are frequently developed as one-size-fits-all. This is despite knowledge that nurses' brains are highly individualized. (5,6,17,18,31) Also, nurses continually access and modify their brains during a shift, but portable, tailored electronic handoff tools are not yet available. (5,6,32,33) Handoff tools have been recognized as cognitive artifacts—objects that provide cognitive support by offloading a cognitive work from the human mind to an external object. (6,17,18,31,34) As cognitive artifacts, nurses' personalized brains provide support for organizing tasks, synthesizing information across sources, as well as transferring information during inter-shift handoff. However, research has yet to examine how, when, or why brains are used throughout a shift—fundamental information needed to design an effective, usable electronic handoff tool. It is even possible that computerization of handoffs is too complex to accomplish once they are fully understood.

5. Methods

5.1 Study Design

Grounded theory methods were used for data collection and analysis. Data collection occurred in two phases. The first phase will involved field observation and was completed before funding for this project began. Participants for shadowing completed during Phase 2 were chosen using observations from Phase 1.

5.1.1 Setting

The setting for this study is the medical oncology unit in a cancer specialty hospital located in the Intermountain West. This 50-bed hospital provides care for thousands of patient each year and employs approximately 35 staff nurses. This setting was chosen because the PI has prior experience conducting research in this setting, and nurses working in the medical oncology unit have demonstrated interest in participating in research studies. In addition, focusing on a single unit allows for a complete understanding of nurses' brains, without the need to fully understand multiple cultural contexts.

5.1.2 Participants

A total of 73 hours of general field observations were completed during Phase 1 between August and December 2012. A total of 129 hours of shadowed observations were completed during Phase 2 across 13 nurses between February 2013 and July 2013. All 13 shadowed participants were staff nurses on the medical oncology unit. The median length of nursing experience was 4.5 years, ranging from 7 months to 34 years. Experience on the unit ranged from 6 months to 34 years, with a median of 4 years. The majority of nurses held Bachelors degrees, though two nurses held Associate degrees and one nurse had a Masters. All but one nurse were female.

5.1.3 Data Collection Procedures

The data collection procedures for this study included field observation, shadowing, interviews, and artifact collection. Field observation occurred during Phase 1 and data collected included field notes and informal interviews. Shadowing, formal interviews and artifact collection occurred during Phase 2 and data collected included field notes, transcripts of formal interviews, and artifact collection. All data were digitized and collected into Atlas.ti (35) for analysis.

5.1.3.1 Phase 1: Field Observation

Data collection during this phase included field observations on the medical oncology unit and informal conversations with nurses. During this initial period, the PI informally observed activities on the unit over the course of 73 hours of observation. This period allowed the PI to gather an initial understanding of the social context of the unit and how nurses' use of brains fit into that context. This time also allowed nurses and others on the unit to become acclimated to having the PI on the unit, a rapport to develop between the PI and potential participants for Phase 2, and reduced the tendency for nurses to modify their actions when the PI was present. Each observation during this period began at least 30 minutes prior to a scheduled shift and completed at least an hour after the shift finished. During the period prior to a shift beginning, activities nurses used to prepare their brains prior to starting a shift were noted. Similarly, during the period following a shift, how nurses use their brain to finalize their work before leaving the unit was observed. The PI paid particular attention to nurses producing and interacting with their brains, recording in field notes any emerging concepts and research questions to explore further in later observations.

Field Notes: Observations from this period were recorded in 55 pages of detailed field notes. This included the PI's thoughts and impressions of observed events, and issues and questions to pursue as research continued. The PI used field notes to gather reports of events and interactions of interest, as well as individual interpretations and possible meanings these events might have for participants. Immediately following an observation period, the PI reviewed and expanded information gathered in field notes. Thus, field notes were closely tied to field observations temporally and in intent.

Informal Interviews: Informal interviews occurred when the PI approached individuals on the unit for further information about events observed during field observation. These were short, informal interactions specific to the observed event. For example, the PI asked a staff member how he recognized a paper brain could be shredded after he was observed doing so. Notes describing these events, the clarifying question(s) asked, and the responses were written in field notes either during the informal exchange, or a soon after as possible.

5.1.3.2 Phase 2: Shadowing, Semi-structured Interviews, and Artifact Collection

Data collection during Phase 2 included shadowing individual registered nurses during a shift in the medical oncology unit, semi-structured interviews with shadowed individuals, and collection of digital scans of nurses' brains.

Shadowing: The PI observed nurses creating and using their brains in different contexts by shadowing participants during an entire shift. Shifts of 8- or 12-hour duration were observed during Phase 2. ADD A SENTENCE ABOUT HOURS OF OBSERVATION TIME. Observation began immediately after obtaining informed consent for study participation upon arriving on the unit. The PI shadowed the participant throughout the shift, taking note of when and what is happening when participants accessed and/or modified their brain. Observation ended after the participant completed the shift and clocked out—usually 30 to 60 minutes after the shift ended. Data collected during shadowing was recorded in field notes.

Semi-structured interviews: Semi-structured interviews were conducted with participants immediately following the shadowed shift in all cases except one. In this case, the interview occurred during a night shift at approximately 02:00 during a lull in the nurse's activities. Participants were asked about the structure and content of their brains, how they learned to make a brain, how and when their brains were created and destroyed, and specific events that occurred during their shifts. Participants' brains were used during the interviews to help elicit responses.

Interviews were audio recorded, and audio files were transcribed to a rich text file by a professional transcriptionist. The PI compared transcripts to the audio files for accuracy, and de-identified the files by removing all personal health information about patients and any identifying information about providers and participants.

Artifact Collection: Artifacts are the physical objects that individuals interact with in their social context.⁴⁶ Nurses' brains are considered artifacts and digital images of nurses' brains were collected. Digital scans of participants' brains were created using a portable digital scanner. Scans were saved to an encrypted drive while on the medical oncology unit. These files were transferred to an encrypted server and were de-identified by blacking out patient PHI and identifying information about participants and other providers. Scans of brains were collected 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 3) immediately after the participant completed giving handoff. These time points occur at natural breaks in the nursing shift and allowed examination of the original content and structure of brains, any changes made to brains during the shift, and any additional changes made while giving handoff to the next shift. Interrupting a nurse's shift more frequently had the potential to disrupt workflow, impeding the observation of nurses using their brains in a naturalistic way.

5.1.4 Analysis

Grounded theory's signature methods of theoretical sampling, constant comparative analysis, codes and categories derived from the data, analytic memo writing, and theory generation were used. The constant comparative method was applied throughout the study, beginning with initial field observation. Data in all forms, once collected, were scrutinized using three phases of coding--Open, Axial, and Theoretical--as described by Saldaña. (36) Analytic memo writing began with initial participant observation and was used throughout the study to generate ideas, explore thoughts and interpretations, and evaluate and reflect upon the activities of the study and theory generation.

6. Results

6.1 Aim 1: A Grounded Theory of Paper Brains

Four main concepts emerged from the analysis of the data: brains provide cognitive support, brains are a representation of nurse identity, brains represent the patient, and brains are living objects. These concepts are explained in detail in the following sections. Further development of these concepts into a substantive theory of nurses' paper brains is currently underway. Participants' names have been replaced with pseudonyms to protect their privacy.

6.1.1 This is How I Think: Brains Provide Cognitive Support

Paper brains have been described as cognitive artifacts. As such, the paper brain provides cognitive support of nursing practice as a place to store information for later retrieval, to list tasks, and to organize and prioritize those tasks for efficient and safe patient care. Yet, this content must be presented in a manner that works with the nurse's way of thinking about patients and nursing practice. Despite this individuality, paper brains have general types that reflect these differences among nurses, and content varies across brain types. In this section, brain types will be described first, allowing differences in content across types to be explored.

6.1.1.1 No Need to Reinvent the Wheel: Paper Brains Have Types

As described in previous studies, (5,6) nurses' paper brains are individualized. Nurses in this study explained that the process of synthesizing information and the way it was represented on the page was specific to the individual.

Keira: I think everybody's brains work differently, as in their literal brains, and so they process things [differently]— some people are more like visual and they like things spaced out a certain way. Some people like it to be like super condensed and tiny handwriting, and I hate that...And I think that's why so many different styles have evolved, because people want them to be their own and to reflect like how they function, how they work, how they view things. So, I don't think one standard thing would ever work...Like, if some people are very like regimented and they like things like in boxes and stuff and other people just like to like free-flow and write everywhere, those different styles aren't going to agree on the same type of form, so.

However, they recognized that information included on their brains was likely very similar, "It's not that we're so unique; we all need the same information, but we are unique in the way we process it and we synthesize it." (Mary)

Though no two brains in this study were completely identical, all brains could be categorized into three general designs: 1) hand written free-form, 2) pre-printed templates or skeletons, and 3) the Nursing Summary Report generated by the EHR. All brains, regardless of design, have internal consistency across patients. In other words, none of the nurses would have one template for one type of patient and a different template for another type of patient. A blank brain represents part of a nurse's schema of all potential patients. Data for specific patients assigned for a shift would be copied from the EHR, an old paper brain if a nurse had previously cared for a patient, and from report given during handoff.

6.1.1.1.1 Free-Form

Free-form paper brains are hand-written by the nurse without a pre-printed structure. Four of the 13 nurses interviewed used a free-form brain at the time of their interview. Free-form brains generally began as a blank piece of paper taken from a laser printer on the unit. However, one nurse on the floor used a page designed for progress notes for the defunct paper charting system. This page was lined and labeled "Staff Notes" at the top. Free-form brains could be oriented portrait or landscape on the page, and were created so information for 4 to 8 patients would fit on a single piece of paper. Nurses wrote information for multiple patients on their brains so only one sheet of paper would need to be carried with them during the shift. These areas were separated by either folds, lines drawn by the nurse, or both. Lines were drawn free-hand, or using a make-shift straight edge like another piece of paper or a laminated telephone reference card from the nurses' station. Patient sections were made before or during safety rounds, and were always ready by the time the nurse received the first report during handoff.

Though free-form brains began as a blank piece of paper, they had a definite, stable structure for where information was written. This structure was consistent across patients and across shifts. For example, a nurse might always write the patient's name, age and room number in the upper left corner, and the most recent laboratory values along the bottom in the center. This structure was apparent to the nurse who created the brain, but not necessarily to other nurses on the unit. Zoe, a well-respected nurse with more than 30 years of experience, used a free-form brain. Two other nurses on the floor explained, "She just writes stuff," and "She just writes things down anywhere." Though others could not readily see how she structured her brain, Zoe was easily able to describe how it was organized when asked to do so.

6.1.1.1.2 Skeletons

Skeletons are paper brains that begin as blank templates and were the most common type of brain observed on the unit (7 of the 13 nurses interviewed). Skeletons generally have sections designated by lines or boxes for different types of information. These sections could be labeled or unlabeled. Information would be filled out in pen or pencil by the nurse at the beginning of the shift. Several photocopies of blank skeletons were kept in nurses' lockers. A single blank skeleton would be pulled from the locker before report to be used as the shift's brain. Like free-form brains, skeletons could be oriented portrait or landscape on the page. Generally, skeletons were double-sided and designed so 4 to 8 patient areas were printed on a single piece of paper; however, one skeleton that was originally created for use in the Bone Marrow Transplant unit was designed so only a single patient was on each page.

6.1.1.1.3 Nursing Summary Report

The Nursing Summary Report is a form generated by the EHR that was designed specifically for the hospital to be used for nurse handoff in acute care units. This type of brain was used least often by nurses on the unit--only 2 of the 13 nurses used the Nursing Summary Report exclusively, and one nurse, Mary, was using both the Nursing Summary Report and a free-form brain. The report is designed to be printed portrait-oriented on a single letter sized piece of paper, one patient per page. Different categories of information are printed in sections separated by lines. For example, the last five sets of vital signs are printed in one section, and medications and orders are printed in another. Every nurse who used the Nursing Summary Report wrote additional information on the form prior to and/or while receiving handoff.

Some information that had been printed on the Nursing Summary Report was often rewritten by the nurse. One example of this was lab results. Lab results printed on the summary report are displayed in an alphabetical list and are not clearly grouped into related tests. Individual results of complete blood count (CBC) and basic metabolic panel (BMP) tests were mixed together in this list. Every nurse who used the Nursing Summary Report would recopy those values into a fishbone diagram s/he would draw elsewhere on the page, allowing inferences to be made through the visual grouping of data. Diet orders were another type of information rewritten to be easily referenced by the nurse while on shift. In addition, depending on the complexity of the patient, some orders may not print to the Nursing Summary Report because of lack of space. Nurses would review those orders in the EHR and add pertinent orders to the printed form by hand.

6.1.1.2 We All Need the Same Information: Brains Have Content

The content of paper brains in this study fell into 21 broad categories: Patient Identification, Admission Demographics, Alerts, Problems, History, Patient Preferences, Physical Findings and Assessment, Equipment, IV Access, IV Fluids, Consultations, Procedures, Protocols, Vital Signs, Intakes and Outputs, Pain, Medication Orders, Other Orders, Lab Results and Cultures, Tasks and Reminders, and Contact Information. Every type of brain contained information from each category; however, the Nursing Summary Report printed some information that was not seen in any of the free-form or skeleton brains. These included patient identifiers like medical record number, admission demographics like unit and hospital name, and many lab results. Information that was not printed on the Nursing Summary Report that was handwritten by the nurse included a detailed medical history, IV access, assessment, and orders missing from lack of space.

Individual data items were grouped roughly into these categories within each patient. However, all but one skeleton brain and every free-form brain had an area displaying data items from across multiple categories that gave a picture of patient context representing the “story of the patient” as described in later sections. Patient identification, admission demographics such as room number, diagnosis, and reason for admission were nearly always presented together. Alerts were grouped with this information as well, except in Nursing Summary Reports where alerts such as fall risk and one-to-one observations were printed among all patient care orders. Nurses would recopy or highlight this information to make it more visible. The information in free-form and skeleton brains were described in interviews as being ordered according to how information was presented when giving handoff.

Along with these categories every brain had a schedule of medications due and other time-sensitive tasks. Schedules were either made for each individual patient, or collected into one comprehensive schedule with all patients combined. Two general formats were observed for the single-patient variety. In the first format, every hour of the shift was displayed with an indicator of a medication or task due for a subset of the hours. Indicators were either a simple visual like a checkmark or circle around the hour label, or the name of the medication or task. Medication names were often spelled out conditional on whether the medication had a specific preparation or was particularly time-dependent. Examples given were medications that needed to be re-suspended in a liquid, and time-sensitive antibiotics. The schedule listing all hours of a shift was exclusively used on skeleton brains. Six of the seven skeletons had schedules of this type.

The second form of single-patient schedule displayed a list including only the times the patient had a medication or task due. Again, indicators of tasks or medications due were either simple boxes or spaces to check off, or the names of medications or tasks spelled out. The limited list schedule was used by two of the nurses with free-form brains and two of the nurses with the Nursing Summary Report.

The comprehensive schedule included all patients, and took the form of a grid with the hours of shift along one axis and the patients labeled by room number, name, or both along the other axis. The comprehensive schedule was seen on one free-form brain and one skeleton. This skeleton was the only one of the seven skeletons that was not identical on each side. Mary, who used both the Nursing Summary Report and a free-form brain, used both the limited list for each patient, and a comprehensive schedule with all patients included. Mary indicated in her interview she added the limited list to her free-form brain in addition to the comprehensive schedule only when using the Nursing Summary Report.

6.1.2 It's a Part of Me as a Nurse: Brains Are a Representation Of Nurse Identity

It became apparent in this study that the support paper brains provide goes beyond mere information retrieval. Brains are personal representations for the nurse and act as a means to assert autonomy in a larger healthcare system. Not only are nurses' brains individualized, but they are also personal. Many nurses, especially those who used free-form or skeleton brains, would talk about how their brains were an expression of themselves and how they think.

Jane: I just feel like this is my personal---like no one---it's no one else's.

Interviewer: As you hug that to yourself.

Jane: Exactly, yeah... Like I'm giving you a piece of myself there with my brain.

Sharon felt similar and said without her brain she could not practice, and would have to retire adding, "Like this is my brain...And so, yes, it's a part of me as a nurse." Nurses who used the Nursing Summary Report indicated their brains represented them as a nurse to other providers and their patients.

Keira: When the patients are asking a question, like, “Oh, what were my counts today?” I say, “Well, let me look,” and I pull out my paper. And so that's impressive to them to know that I already looked it up and I have it written down.

A nurse who was floating to the medical oncology unit during field observations felt the Nursing Summary Report looked more professional to others than anything hand-written.

Physicians and other providers were also observed carrying papers with them containing patient information during a shift, though they were not viewed as personal, i.e. as representing the person who printed them out. For physicians, physician assistants, and nurse practitioners in particular, these papers were printed documents from the EHR, such as the History and Physical, or Progress Notes. These papers were referred to as “notes” by those carrying them, and had fewer handwritten pieces of information on them compared to nurses' brains. It was clear these notes were not viewed as personal in an interaction observed during morning rounds between an attending physician and a resident. The resident in this case had printed multiple documents from the EHR for the patient being discussed, including several pages of EKG output. All the pages had been stapled together. While discussing the patient, without asking permission, the attending took the packet from the resident and pulled each page from the staple, spreading them out on a rolling desk in front of him. After finishing the discussion, the attending gathered up the resident's papers in a different order than they had been stapled together, and handed them back to the resident. The resident did not seem upset by this, though the attending did utter a quick apology as he handed the papers back and headed into the patient's room. This exchange was disconcerting because treating another nurse's brain in such a way would be a tremendous breach in etiquette. Though nurses shared information from their brains by showing them to others, a brain was never taken from another's possession.

Nurses respected the difference among other nurses' brains, acknowledging that it was important to allow individuals to express themselves in their work.

Interviewer: Do you think it's important to maintain that individual reflection of personality [in your paper brain]?

Keira: Yeah. I think it's directly connected to how you feel about your job, too, because if you felt like everyone's making me do this, but I'm not that way and I don't like doing it that way, then you're going to feel like you're the odd one out and you're the one that's being made to conform. So, I think it is important to let people have their own style.

Keira was not the only nurse to discuss the connection between paper brains and job satisfaction. Olivia and Mary also discussed how their brains expressed their autonomy as nurses. Olivia mentioned while being shadowed that using her own individualized brain was a way to “thumb her nose at the administration” and maintain autonomy in her practice after being “strongly encouraged” by the organization to use the Nursing Summary Report. She was open to changes suggested by the organization that might enhance patient care, but felt that forcing her to use a different brain was not the way to do it: “I don't like arbitrarily being told what to do. I like autonomy.” Mary, who was trying to use the administration-supported Nursing Summary Report instead of her free-form brain, was clearly uncomfortable with the change. She saw the Nursing Summary Report as a representation of what the hospital administration viewed as a good nurse, though it did not mesh with her own identity as a nurse. In her interview she discussed trying to reconcile the differences between the Nursing Summary Report and her own nursing practice:

Mary: Sometimes I feel like... what I end up prioritizing as a nurse here, is very different from what is prioritized on other units. So it's like, well, if I get used to using this [Nursing Summary Report], maybe I'll be a more efficient nurse. Because I'm listening to [the nurse manager] talk about how we're not managing our time well, and how we should be able to carry bigger patient loads. And I'm like, well, you know, if all I paid attention to, to some extent, was the information that they feel is important enough to include in the nursing summary, maybe I could use my time more efficiently. But then, if all I do is use what actually appears in the nursing summary notes, 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. So I'm trying to use this and maybe get back in touch with what the administration thinks is a good nurse.

[I give report from the Nursing Summary Report] because I have noticed that there are some things that I don't consider that important, but that appear here [on the Nursing Summary Report], and I don't want to be remiss in telling somebody about, in the event that they, too might find that important, where I would take for granted that they would know it...So I do use it to remind me that there are sometimes things that I need to pass along that I think are either self explanatory or not as important as the other things that I'm going to tell you about....Right now I am really-- I'm trying to make sure that what I'm giving [in report] is part of the party line....But this way necessitates me having stuff here, stuff here, stuff here and more stuff here [points to several areas on the front and back of her Nursing Summary

Report], because what I usually do is I usually pull it out [and copy it to my free form brain] in my schedule and...[list of patient] problems. And that's usually what I work off of [during my shift]. And it works much better for me.

Mary's discomfort with using the Nursing Summary Report is clear in her interview, and demonstrates a disconnect between its structure and how she practices nursing.

6.1.3 I Almost Hugged Mine: Brains Represent the Patient

Paper brains are a representation of nurses' patients beyond mere information. For some nurses, paper brains act as a physical manifestation of the patients themselves. Brains are also a place to save a narrative representation of the story of the patient.

6.1.3.1 Brains Are a Physical Representation of the Patient

Nurses, especially those who used free-form and skeleton brains, described looking at their paper brains to help them visualize their patients in their minds. Betty and Jane both described using their paper brain to generate an image of each patient while charting results of adult patient assessments. Both indicated that if they could tie the information to an image of the patient, they could remember the actual assessment and chart more accurately. This was true even though the results of the assessment itself were not written on the paper brain. For Violet, the structure of her paper brain represented the physical location of each patient's room:

Violet: So anyway I think that's why I [take report] in pencil, and so with my type A I just feel like not to have this and have it organized, it just bugs me and it throws me off. Or if they change the schedule or change my patient list and I've already written stuff down but the room order is messed up, that bugs me too. So I would have to either erase it or get a new sheet. But, [when I pick up a new admission] even then, say I started with four patients and then this [patient list] was going to be out of order, I would skip this box and go down to here....Because it has to be in order of where the patients are in my mind and on my paper clearly.

Interviewer: Do you picture the rooms in your mind when you're looking-

Violet: I think so. Yeah.

In a particularly poignant conversation, Sharon was able to illustrate how her brain was almost a material extension of her patients. During her interview, Sharon made an affectionate gesture toward her paper brain. When asked about it, she began to discuss how she feels about her patients.

Interviewer: Okay, so this movement that you just did is really interesting, because I think every single person [I've interviewed] has either petted their brain or hugged it or made some--.

Sharon: I almost hugged mine! Well, I think, you know, I mean you and I have talked about this today, like at least the nurses here on [our unit], I mean it's more than a job. You know, this is our heart, and these patients are our families. They're our second families, and it's just amazing to me that you can meet somebody the first time and really like love them that profoundly, you know? I don't think I've ever really had that experience more than maybe a couple times in my life outside of being a nurse, but I can-- these people, like I genuinely love most of them, and so when people come and make changes to our work, it's hard to not take it personally.

The affection Sharon feels toward her patients was mirrored in the affectionate gesture she made toward her paper brain, indicating a tangible representation of her patients on the paper.

6.1.3.2 Painting the Picture: Brains Hold the Story of the Patient

At the heart of the representation of patient is the story of the patient's hospitalization. Five of the nurses explained during interviews that their paper brains provided a means to construct and store a "story of the patient" that was central to the care they provided. Oncology patients frequently have long disease trajectories spanning multiple hospitalizations. A patient's cancer trajectory can be compared to an epic story comprised of multiple books. Each book in the epic can be thought of as a single hospitalization. As a book is made up of individual chapters, each hospitalization is made up of shifts. Each shift can then be thought of as a chapter written from the point of view of the nurse caring for the patient.

Jane: Because I think that's what we need is the important stuff, the basics, to paint the picture.

Interviewer: Okay. Can you talk a little bit more about painting the picture?

Jane: Yeah, I mean we kind of do that [at report] when we give the history and we give the plan and we give how they've progressed through the day, you know? I mean I think as we-- at least when I have a patient for three days in a row, I can kind of give-- tell where they came from, like this is-- the first day,

they had this and this and this done, and the next day, they had this, and you can kind of see a progression either for better or for worse when you-- it just helps.

Interviewer: Like a story?

Jane: Yeah, yeah. Yeah, their story of hospitalization, I guess.

The nurse's brain is a tool that allows a nurse to construct the story for each chapter, and tell that story to the next nurse who will care for the patient. The story of the patient is constructed at the beginning of a shift during the creation of a nurse's brain, and is updated throughout the shift. Information about the patient is gathered from several sources. These sources include discrete data from the medical record (e.g., previous lab values and prescribed medications), text-based information such the medical history and procedure notes written by physicians, report from other nurses during handoff, and the nurse's own mental schema developed through education and experience. This gathered information is synthesized by the nurse into a narrative about the patient which is central to their nursing practice. Mary explained that the story was at the heart of how she would care for her patients. Knowing what had occurred for the patient previously was directly related to how they would progress during her shift:

Mary: We want to know, what have they had, like, what non-cancer related illnesses have they had, because that can impact their treatment now. Plus when was the last time they got chemo? What was the chemo? Did they have any complications with that? Have they been to the ICU before? There's some chemos that for instance, bleomycin or something, that will-- can cause pulmonary fibrosis, and if they're in for another round of chemo, and they've been neutropenic before, and they've had neutropenic fevers and they've gone to the unit, chances are good they're going to go there again.

The paper brain provides a place to record this information and acts as a representation of this nurse-constructed story of the patient. This is evident in Violet's brain: designed with a space at the center of each patient area. In this space, Violet wrote down a variety of information that gave the context of her patient. Information included IV line information, physical observations to watch for problems, medical history that may be pertinent for this admission, and indicators of how the patient had progressed so far and how s/he might progress during the upcoming shift. All brains contained the contextual information that indicated a synthesized story, but brains belonging to Felix, Zoe, Mary, and Sharon, in addition to Violet's, displayed singular areas specifically for varied information that taken together told a "story of the patient".

The link between the paper brain and the story of the patient is also indicated by the reproduction phase of life cycle of the brain discussed later. Nurses reported keeping their brains after a shift because they were likely to see those patients again. The brain was not deemed ready for destruction until the chapters of the patient's story written by that nurse were finished.

The paper brain provides a space for nurses to store this nurse-constructed story as a whole that is not available to them in formal documentation. The current EHR on the unit was described by nurses as several disjointed screens of data without an easy means to synthesize across pages without the help of a paper brain. Nurses perceived the EHR as being "medical focused," and expressed a need for "just the basics" to provide a "snapshot," or "picture" of the patient.

Mary: [The Nursing Summary Report] doesn't have history, it doesn't tell us that he had squamous cell carcinoma, and I did mention to [the PA]...I said, "do we think that it's anything from his previous cancer," and she didn't really give me an answer. But it's important to have a medical history there and we don't have any-- like, this [nursing summary] report has nothing about a medical history. And if you look at a lot of our brains, I guarantee you that a significant portion of this space will be dedicated to their past medical history.

Mary further discussed that she had not needed a paper brain before the EHR was implemented on the unit:

Mary: [I've been] on this unit for eight years, yeah...For a long time, we had Kardexes, and so you just didn't write it down. Like you wrote down other-- you wrote down some stuff, but you had a Kardex just right there, so you didn't-- I took notes, but I didn't take notes-- I didn't have to write down as much. And when the Kardex went, all that information had to go somewhere.

Paper brains provide a nursing-specific space to store constructed knowledge central to nursing practice that is not currently available in formal documentation.

6.1.4 Brains are Living Objects

During field observations, after hearing an explanation of the topic of this study, a clinical instructor with students on the unit declared, “[Paper brains] are like living things. They aren't just pieces of paper with information on it.” Indeed, like living things, nurses' brains go through a life cycle each shift, and an individual design can evolve over the course of a nurse's career.

6.1.4.1 Life Cycle of a Brain

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' brains, like living organisms, go through a similar series of phases. Birth occurs with the creation of a new brain at the beginning of the shift; middle age is the use of the brain during the shift; death occurs with the destruction of a brain when it is deemed no longer useful. Reproduction can be seen as the transfer of information by the nurse from an old brain to a new one.

Brain creation occurs while a nurse prepares a brain for use during the shift. This happens before, during, and after receiving handoff at the beginning of a shift. Nurses will begin with an initial version of their personal brain. This may be a blank sheet of paper for a free-form brain, an empty skeleton, or a printed Nursing Summary Report depending on the nurse's preference. Information about the patients to be under their care is gathered from multiple sources, synthesized, and transferred to the new brain. Creation is complete when a nurse feels in possession of enough information to begin patient care. Rarely did this occur immediately after report was finished. Most often 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 brain creation before moving on to patient care; however, this was not always possible. In most cases when tasks were required to be done before a nurse's brain was complete, the nurse leaving shift or the charge nurse would try to take care of any immediate patient needs. This allowed the oncoming nurse to finish creating the brain before moving on to patient care.

The next phase in a brain's life cycle is “use.” This is the process of utilizing a paper brain during a shift and is the middle of the life cycle. Use begins after a nurse completes creating a brain and begins actively caring for patients, and use ends when the nurse determines the brain is no longer needed. This end point varies among nurses, ranging from immediately following giving report at the end of a shift, to a couple weeks or months following the shift. Nurses, especially those who favored a free-form or skeleton brain, reported storing their brains for future reference. The process of synthesizing patient information into a coherent whole is time consuming, and nurses expressed a desire to not repeat the process once it had been done. Old brains are kept beyond the primary shift so information previously synthesized, especially prior medical history, psychosocial concerns and patient preferences, can be reused on subsequent shifts. The process of transferring information from an old brain to a new brain during creation is analogous to reproduction in the biological life cycle. Old brains are stored in the nurses' individual lockers until they are deemed no longer needed and destroyed. Nurses mentioned being more likely to hold on to a brain if they were scheduled to work the next several days in a row because they would likely be assigned to the same patients.

During the use phase, the brain's purpose is mainly as a cognitive artifact--providing a place to organize and prioritize tasks, to store information for retrieval at a glance, and to store general information like telephone numbers for quick reference during the shift. The brain also acts as a storage space for the nurse's constructed “story of the patient” and is the main source of information for handoff to the next nursing shift. During shadowing observations, nurses were observed using their brains to store information “on the fly.” Vital signs reported from CNAs, intake and output values for future charting, observations for communication to others, and results of tests and procedures were all jotted down on paper brains for future retrieval by the nurse. Information retrieval occurred while the nurse was charting, or in communication with another person. Communication occurred with other providers, patients, and patients' families. A major part of the use phase is task organization. Nurses used their brains to keep track of tasks pending and completed. New tasks would be hand-written on each brain as the shift continued. In addition, brains were used as scratch paper to make calculations, take personal notes like book recommendations, and for doodling. Doodling most often occurred while the nurse was waiting either to give handoff or for a time-sensitive task due within minutes; however, in one case, Violet used her brain to sketch a chemotherapy intravenous infusion device. Violet used this sketch to demonstrate proper taping technique to a novice nurse.

Beyond cognitive support, paper brains may also provide a subtle sense of safety or security for nurses. All nurses spoke of feeling safer knowing that if the electronic medical record went down, they had the information they needed to care for patients with them in a “crash-proof” format. Frustration with the unreliability of electronic formats was a frequent occurrence on the unit, and mentioned in multiple interviews. In every shadowing observation, a nurse would experience problems with logging into the EHR at least once during the

shift. Difficulties with the printers for the newly implemented barcode medication administration system were also observed, though the frequency of these problems decreased with time after implementation.

The final phase in a brain's life cycle is destruction. Destruction is the process of destroying the brain after it is deemed no longer useful. As mentioned above, destruction can occur immediately following a shift, or several weeks after. For nurses using the Nursing Summary Report, destruction occurred immediately following a shift. These nurses would place their brains in "the shredder"—a locked box used to store sensitive documents for later shredding in bulk---as they left the unit at the end of their shift. Nurses who stored old brains in their lockers reported destroying their brains either after the last shift in a series of consecutive shifts, or when they cleaned out their locker.

Paper brains are most often destroyed by the person who owns them; however, it is acceptable for others to destroy a brain if it is determined to be abandoned by its owner. This occurred twice during field observations. In the first instance, the Health Unit Coordinator (HUC) was tidying up the nurses station after handoff had been completed. He was gathering up stray papers to be thrown away or shredded. One of the papers was a nurse's brain left next to a computer workstation. He unfolded it, looked at both sides, and looked from the patient board to the paper brain. He said to himself, "This is old," and put it in the shredder box. When asked how he knew it was old, he explained he checked the patient names against the patient board. One patient listed on the brain had been discharged the day before, so it was safe to assume the brain was no longer needed by its owner. In the other observed instance, a nurse found an abandoned brain while charting at a computer in the nurses' station. She said, "Oh, this is Jane's. She's gone home," and put the paper brain in the shredder. This nurse explained she had received handoff report from Jane for one of the patients listed on the brain at the beginning of the shift. She recognized the owner of the brain through the patient name, not by recognizing the brain itself as belonging to Jane. In interviews nurses described discovering the owner of an abandoned brain most often via patient names, though some brains were recognizable by their design for nurses they frequently worked with.

6.1.4.2 Evolution of a Brain

Just as nurses' brains exhibit life cycles, 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. Nurses' brains can be viewed to experience their own evolutionary process. Evolution in a paper brain is triggered 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. In such a case, with each new nursing shift and brain 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, but not necessarily perfect. Three types of change events that brought about evolution for the nurses in this study are described below.

6.1.4.2.1 A nurse's first brain

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

Lucy, a nurse with less than one year of experience, was seen using three different brains during field observations: the Nursing Summary Report, a one-patient-per-page skeleton developed for the Bone Marrow Transplant unit, and a modified version of Olivia's skeleton brain.

Lucy: So I am a new nurse. I just graduated last May, and I've only been here...almost a year. So I've gone through several different report sheets, like brains, to find out what works best for me. I did this one off of [Olivia], because she has one very similar. Hers is different in that she doesn't have this area. But there's things that I still feel like I need to change.

Preceptors would help students in the development of their brains by describing what information was important to include in a brain, but would stress that the format had to work for the individual. During one field observation before handoff began, a nurse preceptor explained to a student that the specific format of her 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 brain to use for the shift, but this student declined because she had a form provided by her clinical instructor that she had been using for over a semester. Mary, a nurse with over ten years of experience, explained during her interview how she taught students about brains:

Mary: I will say, "this is how I do it." I don't care how you write it down but when we leave here...before we walk into a patient's room, [I want you to] be able to tell me why they're there, what we're worried about, what their labs are, and what their clinical status is, who we're going to call and why we're worried about it, or why we're going to call them....And then I'm probably going to look at what they've written down and I'm going to let them work with it a little bit... I'm going to see what they add throughout the day... It would be one of the first things we worked on, but it would be over the course of several days to say, "Okay I see that you got this, so you didn't get this or you have all of this; you may not need that; we're getting more bogged down in that."

Two nurses spoke of "just figuring out" how to make their first brain. Both discussed having a feeling of being lost or overwhelmed on their first day during handoff. Zoe mentioned, "I just kind of looked over other people's shoulders and saw how they--- and took a little bit from here, little bit from there, and just developed it myself." Gretchen explained that her 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 brain now corresponds with a section in the student report. She said that if the instructor wanted to know that information, it was probably important to know, so she writes it down on her brain.

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

Interviewer: And has [your brain] always looked like this?

Zoe: No. 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 like where I would keep track of intake and output and then separate out where the IV information went and separate out. It was a little more structured.

For Zoe, the evolution of her brain was not a difficult process. In contrast, Mary was in the process of moving from a free-form brain that she had been using for several years to the administration-supported Nursing Summary Report at the time of her observation. For this nurse, the transition was not going well.

Mary: So I've been printing out a summary report for the last, probably three weeks, somewhat regularly. I don't do it every day. But I noticed while I was floating [to other units], that everybody uses these, and that sometimes they have them preprinted for us when we get there, and that. So I watched what some other nurses were doing and I noticed how they were filling in the information, and I thought, well I can try that. But I do not find that, in general, it leaves me ample room to get patients' back story, more details about what they need for their chemo, details about treatment. It's difficult when you start really writing in a lot of stuff, to see, if somebody's neutropenic, it's difficult to see when their last blood cultures were and what they're doing... So I'm trying to use this...and to say, okay, when I float, I can use this to organize, but it really just means more paper that I carry around and more places that I have to look for stuff...I don't have plans to do this-- I mean, I'm going to try it for probably another week or so, and then I won't do it unless I float, I think.

6.1.4.2.3 A new job

Sometimes the change that triggers evolution of a brain is a move to a new environment all together. A brain must be able to support the nurse in their new environment. Nurses who had come to this unit from another hospital spoke about only needing to update their brains from their previous jobs to include information specific for medical oncology patients. Violet pointed out that she now writes down information related to

chemotherapy, such as protocol, cycle number, and treatment day in a space on her brain that was designated for just diagnosis when she worked on a different unit.

Felix was particularly unique in his readiness to adopt a new form when hired on a unit. When asked how he learned to make a brain, he responded, "I don't know how to make a brain." When pressed further, he explained that he was always given a brain to use when starting at a new unit.

Interviewer: How did you learn to make a brain?

Felix: This one was given to me. Actually, I don't know how to make a brain. [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....I wish I was motivated enough to go home and make one. Usually I want to eat dinner and go to bed.

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 brain formats. At the time of her interview, she felt the brain she was currently using would be the one she kept, but explained that she would be willing to change it, if she had to or if she found something better.

Lucy: I have absolutely no emotional connection to this piece of paper. [chuckles]

Interviewer: No emotional connection. Okay. That's interesting.

Lucy: No. I don't. It is what it is. And if someone showed me something better, I would drop this thing in a heartbeat. It doesn't matter. It doesn't. So. But again, I'm still learning, and I'm still learning what's best for me. So. Maybe when I'm--- like 20 years from now I'll be like, "Don't you talk about my brain!"

This exchange was in stark contrast to more experienced nurses who would make comments in passing such as, "Please don't take my brain away," and "Don't take my brain. I'll have to retire."

6.1.4.2.4 It's Good Enough: Stabilization After Evolution

After any process of brain evolution, the design would eventually stabilize into a format that was considered "good enough" by the nurse using it. Olivia said, "There's things I would change [about my brain]. This isn't perfect, but it's good enough. It works for me." This type of stabilization was most apparent in the skeleton brains. All but one of the nurses using a skeleton format expressed a similar sentiment, mentioning small things they wanted to change about their brains, but had not yet done so. Making the space designated for medical history and assessment larger, deleting an area designated for intake and output they no longer used, and adding or removing labels were all given as examples of desired changes. 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. Olivia mentioned that her template was created in a version of Microsoft Office that was out of date, so she was unable to access it for editing. Felix and Gretchen had only a paper-based version of their skeleton and would have to re-create it in electronic format to make any changes. This was seen as an unnecessary burden since their brains were viewed as "good enough."

For people who used a free form brain, there was less of a barrier for change. These nurses could just instantly make the change while receiving handoff at the beginning of a shift. For example, Mary explained that she had added a box around IV access information "at some point 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 brain showed signs of solidification. Zoe's brain showed 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 actually useful for her, she continued to write the labels on her brain for every patient.

The Nursing Summary Report exhibited solidification differently because the nurse could not change what information was included in the printout, and the printout itself was fairly dynamic. Though each predefined section of the Nursing Summary Report would print in the same area, certain sections---particularly orders and labs---could vary greatly in size based on the amount of information stored for each patient. Data could be truncated, or left off completely, and specific orders would be in different locations within the section across patients. Nurses addressed this variability by rewriting orders in the same location on the page, or by highlighting the order to make it easier to find. The amount of free space for additional note taking could vary greatly across reports. This required nurses who used the Nursing Summary Report to be more flexible about where they would write additional information, and how much space they needed to do so. Kiera would consistently write the times medications were due, fishbone diagrams, and pertinent orders in the bottom margin, regardless if there was printed space for notes. In contrast, Collette would fill in labels for the body

system for patient assessment for each patient, and would adjust how much room was used based on how much was available.

6.1.5 Discussion

6.1.5.1 Brains Provide Cognitive Support

Nurses' paper brains have been characterized as cognitive artifacts. (6,15,17-19,31) Cognitive artifacts support individuals by offloading part of the cognitive work required by the human mind to an external object. Jones and Nemeth (37) claim that cognitive artifacts are an embodiment of cognitive support needs because they are created by the individuals who use them as an essential part of workflow. Because human beings vary in cognitive abilities and work styles, nurses' brains are expected to exhibit differences across individuals.

Though nurses' brains are individualized for use by a specific nurse, similarities across brains exist. The brains observed in this study fell into three broad types: free-form, skeleton, and the EHR-generated Nursing Summary Report. Nurses in this study expressed that they used a specific format because it matched how they thought about their patients and their practice. Nurses respected differences among formats, recognizing that though their particular format worked for them, it might not work for everyone. Still, nurses were happy to share their individual formats with other nurses to help them find what might work in their practice.

These results align with previous research about the variety of informal handoff documentation. Hardey, et al. (1) observed that informal handoff documentation is designed and owned by individual nurses. The results of Stagers, et al. (6) described continued use of tailored paper-based tools designed by individual nurses, despite the availability of a computerized form integrated with the EHR. In a report of a quality improvement project, Klee, et al. (2) state that the development of a single, standardized tool to replace the numerous individual forms for handoff was a fundamental goal of the project. The results of this study suggest, however, that standardization into a single form may not be recommended. Multiple versions of a standardized tool may be indicated to support differences in nurses' cognitive needs and expression of nurse identity. Allowing multiple designs would limit variability in handoff communication as recommended by the Joint Commission in 2006, (38) but still support individual differences in nursing learning styles and internal patient schema.

The content of nurses' brains fell into 21 specific categories. Though the context of this study is different, these categories align with the findings of Collins, et al. (17) in a review of the content in handoff artifacts for nurses and physicians. Though data from every category appeared in all brains, the inclusion of specific items varied across patients within individual brains. According to the nurses in this study, patient context influenced their decision to include specific items, only writing down data items that would add to their constructed "story of the patient." These findings agree with other studies in the literature. (1,6,17,39) Some data items were not printed on the EHR-generated Nursing Summary Report and were added by hand by the nurses. These were items such as prior medical history and recent physical findings that were stored in the EHR as free-text files. Free-text files must first be processed, either through natural language processing methods or by a human user, to abstract the specific history and findings pertinent to the shift. This makes it difficult to obtain a report compiled by the EHR that includes all required data for nurses to know their patients. Future development of tools designed to be completely electronic will need to address this limitation.

The most salient difference in content between the Nursing Summary Report and other types of brains was the number of data items. The Nursing Summary Report printed a comprehensive list of lab results, some of which were never seen in other types of brains. Examples include counts and percentages of specific granulocytes, and detailed results from urinalysis. This difference may be due to a lack of specificity in information requirements given to the designers of the Nursing Summary Report. The Nursing Summary Report was designed with input from acute care nurses working in the University of Utah Hospital System, including staff nurses from the medical oncology unit observed in this study. During interviews for this study, nurses describing the content of their brains used general terms like "labs" and "orders" for groups of data. When asked, "Which labs have you written?" or "Which orders do you need?" nurses would respond with indicators of timing such as "most recent," "last set," or "pending orders," rather than give specific names of labs or orders. Given these tendencies, it is easy to imagine how the Nursing Summary Report came to list all lab results, rather than just the 11 nurses copy into the CBC and BMP fishbone diagrams. Future designs of EHR-integrated report summaries need to take into consideration the information actually appearing on free-form and skeleton brains, since nurses' descriptions of this information may be less specific than required for programmers to develop a usable tool.

As seen in previous studies, nurses in this study used their paper brains as the primary source of information given during report. (1,3-6,19,31,40) Nurses who constructed their own free-form or skeleton brains described the organization of their brains as having a flow that was used to give report at handoff. This

organization gave nurses support when constructing a coherent narrative about each patient and the care that had been given during the shift. Interestingly, the single instance of flow of a brain not matching the flow of report was described by Felix, who claimed he did not know how to make a brain and used what more experienced nurses had given him. In contrast, nurses who used the Nursing Summary Report did not mention the flow of report at all. These nurses spoke only about their brains having the information for report, but did not mention flow.

An aspect of brain organization utilized in all types of brains was emphasizing crucial information. Information that indicated possible changes in patients' conditions were emphasized through placement on the page and mark ups like highlighting or circling. Emphasis worked as a visual trigger to ensure the nurse would be aware of essential information when providing care. Highlighting and circling information allowed nurses to give selected information more visual importance, particularly on the Nursing Summary Report. Visual emphasis supports nurses' need for "at a glance" information retrieval. Though free-form and skeleton brains frequently emphasized information through placement, mark ups were the only way to add visual importance to information in the Nursing Summary Report because of its rigid design.

6.1.5.2 Brains Are a Representation of Nurse Identity

Nurses' brains were presented as personal representations of themselves and their practice. To the author's knowledge, this finding is unique among the literature about nursing handoff. Nurses likened their paper brains to parts of themselves, even showing affection toward the objects through hugs and other similar gestures. Though other providers were observed carrying paper notes during rounds, these notes were less individualized and less personal than those carried by nurses. Nurses were also protective of their brains, expressing fear that this study might result in their paper brains being taken away from them. This was in contrast to other providers who referred to their cognitive artifacts as "notes"--a much less telling word than "brains"--and would willingly give their paper-based notes to another provider to view and modify.

Nurses who used free-form and skeleton brains related to their brains in a more personal way than nurses who used the Nursing Summary Report. Free-form and skeleton brains users would describe their brains as a piece of themselves. On the other hand, Nursing Summary Report users would describe how their choice of brain made them appear professional to an external audience: their patients and other providers. These observations align with the symbolic interactionist concepts of "I" and "Me" as put forth by George Herbert Mead. (41) The "I" is the subjective self, the internal understanding constructed by an individual, i.e. "Who am I?" Free-form and skeleton discussed their papers brains from this perspective---"This is how I work," and "This is who I am as a nurse." The "Me" is an understanding of self derived from interaction with others and the environment, the socialized self, i.e. "How do others see me?" Nursing Summary Report discussed their nursing identity from this external perspective. The nurses who chose the Nursing Summary Report on this unit were younger and less experienced than nurses who chose to use free-form and skeleton brains. These younger nurses may not have had time to develop an internal nurse identity, and so focus may be limited to how others view their brains. For example, Lucy's lack of emotional connection with her skeleton brain may provide support of this view.

Nurses in this study described their brains as an indicator of the importance of autonomy in nursing practice, and discussed paper brains as a means to express this autonomy. Autonomy has been shown to be correlated with job satisfaction, (42-45), and has been described as a defining attribute of job satisfaction in nurses in a recent concept analysis. (46) Paper brains represent a means of having control over individual nurses' practice, leading to a feeling of autonomy in the role of a nurse. Nurse managers and hospital administrators seeking to make changes to the handoff process will need to consider how nurses express themselves through their paper brains. Making sure nurses' individual voices are heard before implementing changes, and allowing individuality to be expressed in paper brains may alleviate unexpected consequences of policy changes.

6.1.5.3 Brains Are a Representation of the Patient

Nurses' brains evidence a need for nurses to further process and synthesize medical information from the EHR into a picture or story of the patient. "Knowing the patient" has been described previously and is believed by nursing scholars to be at the heart of quality patient care. (47-49) Kelley, et al. (40) 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 the authors hypothesized. The results of this study, taken with those of Kelley, et al., indicate nursing knowledge is not sufficiently captured in current EHR documentation in general. This may stem from historical assumptions that nursing knowledge is of less value in comparison with medical knowledge. (50-52)

Knowing in nursing is more interpretive than the objective knowledge traditionally valued by medicine. Knowing in nursing manifests from a profound relationship between nurse and patient that is difficult to articulate. (40,53-56) Sharon's poignant expression of affection demonstrates that paper brains act as a tangible physical representation of this relationship. Within this relationship, knowing arises in the nurse via a continuous assessment and understanding of patients' needs. (40,56,57) The nurses in this study indeed described such a process and told of using their paper brains to construct and store the "story of the patient" for use during the shift. These findings concur with published literature about EHR usability. (5,58-62)

For nurses who favored the free-form and skeleton style, it was clear the story of the patient is at the center of their nursing practice. On these brains, information was often grouped so that patient context, or story, was central. This story informed nurses' decision making by bringing focus onto indications of change in patients' trajectory. This focus enabled a complete picture of the patient as a whole that makes nursing practice different from other providers. Nurses who used the Nursing Summary Report were less likely to describe using their brains to hold a story of the patient. Though their brains display similar synthesis and modifications to bring focus onto indicators of future patient changes, they did not refer to "story" or "picture" when discussing their brains. This difference may be because the information in the Nursing Summary Report is closer to the data stored in the EHR than other types of brains. Story of the patient may be less important for these nurses than for nurses who choose to use a free-form or skeleton brain.

The story of the patient may be particularly important to nurses working specifically in a medical oncology unit. Patients in this unit experience multiple and lengthy hospital stays during their disease trajectory, allowing nurses to develop relationships with the patients. Information regarding how previous cancer treatments were tolerated, previous non-cancer related illness, and psychosocial implications is important for safe and efficient care for the patients as they return to the unit. When patients have a shorter trajectory, nurses may not rely on a paper brain to hold the story of the patient, as that story may be less central to the care they provide. A brain closer to the EHR may suffice. Nurses in this study saw Nursing Summary Reports as sufficient when floating to other units, particularly surgical units where stays could be as short as a day.

6.1.5.4 Paper Brains are Living Objects

The results of this study demonstrate the living nature of nurses' paper brains. Paper brains had a life cycle consisting of four phases: creation, use, 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 long period of time before destruction. Because of the connection between patient trajectory and brain life cycle, brains used by nurses in units with shorter patient stays may exhibit differences in life cycle. In addition to a life cycle loosely tied to shift, brains exhibit evolution across the career of a nurse. Evolutionary changes occur in response to changes in nursing workflow. These two change processes point to the need for flexibility in future designs of standardized forms of brains. Not only will electronic brains need to be easily updated during a shift, but the overall design will need to be re-examined after changes are made to nursing workflow.

6.2 Aim 2: Requirements for the Development of an Electronic Brain

The growing ubiquity of EHRs in hospitals lends a natural platform for the development of electronic tools to support the complex work of nurses. Though a final substantive theory of nurses' paper brains from this study is not yet complete, the initial findings from Aim 1 suggest that a successful electronic brain is unlikely. Previous development of electronic nurses' brains has focused on these objects as cognitive artifacts. Though current options fall short of the minimum of six traits an artifact must contain to support complex work as proposed by Nemeth, et al (63): accuracy, efficiency, reliability, informativeness, clarity, and malleability. Still, the limited view of paper brains as cognitive artifacts ignores that paper brains are representations of both the nurse and the patient. Development of a successful electronic brain will require digital formats to go beyond merely mimicking nurses' paper brains, as electronic formats can impose difficulties that do not exist in paper formats. Given the current state of technology due to limitations of data entry and the size and weight of devices available today, the development of a successful electronic brain is unlikely.

6.3 Limitations

No study is without its limitations. One potential limitation of this research concerns generalizability. As with any study utilizing a grounded theory approach, results may not hold beyond this medical oncology unit. While every attempt to maximize credibility was made following the recommendations of Chiovitti and Piran, (64) it is

possible that shadowing a different set of nurses in a different setting would have yielded different findings. For example, with the exception of Mary, all three of the staff nurses on the unit who used the Nursing Summary Report had less than three years experience as a nurse. A more experienced nurse who chose to use the Nursing Summary Report may have provided additional insights. Further research is needed to determine if the ideas of nurse identity, patient representation, and paper brain life cycles and evolutions hold across other types of units.

A second limitation experienced in this study was the challenge of interviewing participants immediately following the shadowed shift. Both the researcher and the nurse participants experienced fatigue after an 8 to 12 hour shift. Though this time was chosen for the interview to reduce the burden on the nurse, it was difficult to elicit responses from nurses addressing more abstract questions about paper brains after nurses had been task-oriented and focused on information content for an entire shift. Though saturation was reached in this study, the timing of interviews may have limited the ability of both the researcher and the nurse participants to fully explore the possible cultural implications of paper brain production and use. Future studies could use data collection methods such as focus groups or reflective journaling to alleviate this problem.

7. List of Publications

Blaz JW. Out of their minds and onto the page: the production and use of nurses' paper "brains" in a medical oncology unit [dissertation]. Salt Lake City (UT): University of Utah; 2014.

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