# Materiality in Information Environments: Objects, Spaces, and Bodies in Three Outpatient Hemodialysis Facilities

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**The materiality of information environments, and its role in information behavior, has received little attention. We present an ethnographic study involving 156 hours of observation and 28 patient interviews in outpatient hemodialysis facilities. Using an extended "Semiotic Framework for Information Systems Research," the findings show that objects, spaces, and bodies were integral to 6 sociomaterial layers of facility information environments: the physical, empiric, syntactic, semantic, pragmatic, and social world. Objects of importance in the information environments included dialysis machines, instruments, records, paper documents, televisions, furniture, thermostats, lighting, and personal possessions. Spatial features, including compartmentalization, displays, distance, proximity, and spatially-grounded routines, also constituted information environments. The information environments were also shaped by patient immobility, bodily discomforts, and orientation to bodily states. Each sociomaterial layer introduced enablers and constraints to information access, flow, and acceptance; these combined to construct patients primarily as passive recipients of information rather than active seekers and producers of information. A sociomaterial perspective and related focus on objects, spaces, and bodies offers a lens for professional information practice. We contribute information environment design guidance to facilitate such practice and stress that the value of certain sources and types of information can be materially encoded in an environment.**

## Introduction

Information scientists have long recognized a relationship between information behaviors and their environments. Information behavior (IB), defined as "the totality of human behavior in relation to sources and channels, including both active and passive information seeking, and information use" (Wilson, 2000, p. 49), has been examined at the level of the individual-in-context, particularly focusing on the "user's situation" (Courtright, 2007). Researchers have also highlighted the impact of social and spatial proximity to sources on IB (Williamson, 2005).

To a lesser extent, information scientists have considered the IB–environment relationship at the social-group level. People typically share their environments with others, and IB may exist at collective, as well as individual, levels (Talja, Tuominen, & Savolainen, 2005; Veinot & Williams, 2012). While group-level IB research has primarily focused on workplaces, some has examined social groups in "everyday life" settings like retirement homes and rural regions (Chatman, 1999; Veinot, 2013). This work shows that such groups may be less task-focused and role-bound, and more diffusely coordinated, than workplace groups (Veinot, 2009). Accordingly, concepts such as "information grounds" (Fisher, 2005), "information worlds" (Jaeger & Burnett, 2010), and "information environments" (IEs) (Lievrouw, 2001; Taylor, 1991)[1] have been used to understand group-based IB in everyday life. Considering artifacts and institutional and social factors, we focus here on IEs, defined as "social settings or milieux in which … resources, relations and technologies undergo a … process of change called informing" (Lievrouw, 2001, p.12).

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Received March 9, 2018; revised March 12, 2019; accepted May 28, 2019

 DOI: 10.1002/asi.24277

[1] Taylor's (1991) original theory focused on professionals; however, scholars have subsequently applied the concept to lay people (for example, Agada, 1999).

While prior scholarship has identified the role of colocation in everyday life IB, the *sociomateriality* of IEs, and its role in IB, has received less attention. "Materiality," refers to "…the ways in which physical and/or digital materials are arranged into particular forms that endure across differences in place and time" (Leonardi, 2012, p.31). Materiality is important: objects, spatial arrangements, and physical experiences can be informative (Buckland, 1991; Cox, 2018; Godbold, 2013; McCreadie & Rice, 1999; Olsson & Lloyd, 2017; Wolf & Veinot, 2014). The term "sociomateriality" further clarifies that "materiality is intrinsic to everyday activities and relations" (Orlikowski & Scott, 2008, p.455) and "takes on meaning when it is enmeshed with … social" phenomena (Leonardi, 2012, p.38). We focus here on physical matter that can be felt, touched, smelled, tasted, seen, and heard in the social context of hemodialysis facilities.

We present results of a study on the sociomateriality of the IEs of three outpatient hemodialysis facilities, centering on objects, spaces, and bodies (OSB) as units of analysis in these settings. These facilities are workplaces for healthcare professionals, but everyday life settings for patients (Veinot et al., 2010). Additionally, due to dialysis patients' need for health information (Mason, Khunti, Stone, Farooqi, & Carr, 2008), we examine how sociomaterial factors enable or constrain IB within the facility IEs, with a focus on hemodialysis patients' experiences. Significantly, findings show that information, and its relative value, is materially encoded and conveyed within hemodialysis facilities.

## Literature Review

### *The Sociomateriality of Information*

While just beginning in information science research (Blanchette, 2011; Haider & Sundin, 2014; Huvila, 2016), a "material turn" in the social sciences has drawn attention to the materiality of computers and other information artifacts over the past decade (Carlile, 2013), arguing that materiality is essential to human activity. The materiality of environments constrains or enables human activity due to the "affordances" perceived (Hutchby, 2001). A material perspective acknowledges agency, drawing attention to "actions, values, and consequences in context" (Pentland & Singh, 2012, p. 294). A sociomaterial perspective on information holds that information is simultaneously physical, cognitive, and sociocultural; similar to IE theory, it is also both emergent and context-bound (Boell & Cecez-Kecmanovic, 2011).

Within information science, a key focus has been on the ways in which materiality may impose constraints on information access, flow, and use. For example, Lee and Butler (2019) theorized that material aspects of information may coalesce to create local information landscapes characterized by a lack of information access (Lee & Butler, 2019). Bates (2018) stresses the role of sociomaterial factors such as sociocultural factors, infrastructures, and regulations in producing "friction" that impedes the flow of digital information. Jarrahi and Nelson (2018) also outline material constraints imposed by information technologies in the work practices, and related information use, of mobile knowledge workers. Similarly, in the present study we focus in part on material constraints in information environments.

In line with a physical perspective on information, information scientists have increasingly focused on human senses as a source of information (Cox, 2018). In a hemodialysis context, Godbold (2013) and Bonner and Lloyd (2011) documented the importance of bodily states and medical devices as information sources for both patients and nurses. Following this, we focus on OSB due to their centrality in the sociomaterial context of healthcare (Rajkomar, Mayer, & Blandford, 2015; Ulrich et al., 2008). However, we extend the scale of this prior work with a focus on social groups as a whole, and their everyday life information environments.

### *The Informational Dynamics of Social Groups in Everyday Life*

The following IB-related phenomena have been investigated in everyday life social groups: (i) *access to information*; (ii) *dynamics of information flow*; and (iii) *acceptance of information.* We discuss these categories of prior work below.

*Access to information.* Access to information is an individuals' right or ability "to obtain and use information collected or generated by others" (National Library of Medicine, 2013). One facilitator of group-level access is *availability*; social groups facilitate or impede availability through institutional (Jaeger, Burnett, & Thompson, 2016) or normative (Veinot, Meadowbrooke, Loveluck, Hickok, & Bauermeister, 2013) constraints. This work implies materiality because information may not be present in certain locations, and public scrutiny relies upon physical display. However, materiality has not been a major focus of information access research.

*Dynamics of information flow.* Information flow refers to communication of information between senders and receivers (Durugbo, Tiwari, & Alcock, 2013), who may be part of social groups. "Groupness" requires "boundaries" (Veinot & Williams, 2012), which affect flow within and between groups. Boundaries may impede information flow between groups, particularly those with differential power; this may be overcome by "gatekeepers" bringing information from privileged groups into marginalized ones (Agada, 1999; Metoyer-Duran, 1993). Researchers differ in their emphasis on spatial proximity as a boundary underlying groupness (Savolainen, 2009), but have yet to directly consider materiality in everyday life.

*Acceptance of information.* Information acceptance involves "the action or fact of receiving [information] favorably" ("acceptance, n.," 2011). Perceptions of the *relevance* and *value* of information factor into acceptance, and are often shared by groups (Taylor, 1991). Lievrouw (2001) states that IB is contingent upon whether information is perceived as


DOI: 10.1002/asi

relevant within an IE (p. 15). Judgments about information value are normative (Jaeger & Burnett, 2010), leading to reliance on group "insiders" and distrust of "outsiders" (Chatman, 1996). Scholars have also considered the role of objects such as policies, prototypes, and forms in building shared understanding across organizational boundaries (Huvila, Anderson, Jansen, McKenzie, & Worrall, 2017; Meyer et al., 2015; Veinot, 2007). However, the material aspects of information acceptance remain largely unarticulated.

### *Theoretical Framework: Sociomaterial Extension of Stamper's Semiotic Framework for Information Systems Research*

Despite its exciting theoretical implications, the sociomaterial approach remains difficult to operationalize empirically because of questions concerning the ontological separability between the social and the material (Mueller et al., 2012). Stamper's (1991) "Semiotic Framework for Information Systems Research," originating in the organizational semiotics field, was selected for this research as its analytical categories makes the sociomaterial aspects of information environments operationalizable. In line with the sociomaterial perspective, the framework demonstrates that information includes both physical and social dimensions. The framework articulates six "steps"—the physical, empiric, syntactic, semantic, pragmatic, and social world—that build on one another (see Figure 1) (Boell & Cecez-Kecmanovic, 2010) and ultimately facilitate requirements gathering for information systems design. Boell and Cecez-Kecmanovic (2010) extended Stamper's framework by showing its utility for describing the attributes of information in sociomaterial contexts, while retaining Stamper's original "steps." However, they reinterpret Stamper's steps as a continuum of "sociomaterial layers," in which the ontological inseparability of the physical and social layers of information is assumed; we adopt this stance here. Building on Stamper (1991), Boell and Cecez-Kecmanovic (2011) present a view of information as a "sign," or "difference" in the environment; signs may take a variety of forms, including objects, physical gestures, and language (Nöth, 1990). Signs become information to people through their comprehensibility, meaning, and relevance in activities performed in a particular sociomaterial context (Boell & Cecez-Kecmanovic, 2011). We use this framework to examine how layers of physical and social phenomena produce an information environment.

Drawing from this extended framework, we investigate the following research questions:

1. What roles do OSB play in each sociomaterial layer of hemodialysis clinic IEs?
2. What roles do OSB in each of the sociomaterial layers of the IE play in patient IB in hemodialysis clinics?
    a. How do the OSB in each sociomaterial layer enable or constrain patients' access to information?
    b. How do the OSB in each sociomaterial layer enable or constrain the flow of information involving patients?
    c. How do OSB in each sociomaterial layers enable or constrain patients' information acceptance?

## Methods

### *Data Collection*

*Observations.* This multisite ethnography (Hine, 2007) was conducted in three outpatient hemodialysis facilities in the United States. Targeted sampling (Schensul & LeCompte, 2013) was used to select facilities that differed based on geography and structure. In all, 156 hours of observation were conducted (51–53 hours in each facility). Observations ended upon saturation.

The researchers adopted a nonmember role (DeWalt & DeWalt, 2002). Observations were conducted in mornings, afternoons, and on different days of the week to sample different "shifts." Observations focused on physical aspects of the environment (furniture, objects, bodily states), movement in space, and interactions among people and with objects. Informal interviewing (DeWalt & DeWalt, 2002) supplemented observations.

Prior to observation, each participant indicated informed consent. The study was approved by the Institutional

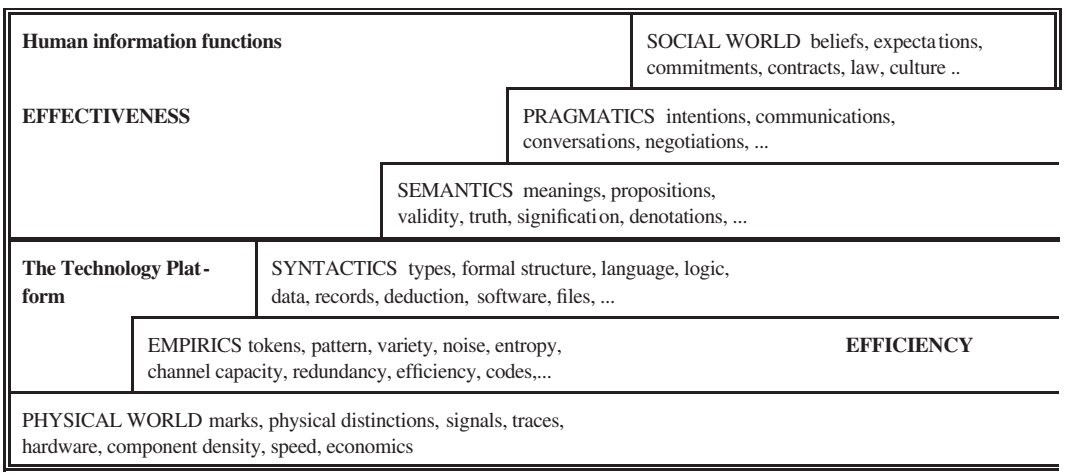


FIG. 1. Stamper's (1991) semiotic framework for information systems research.


DOI: 10.1002/asi

Review Board at the University of Michigan. At each observation, the researcher drew a map of the facility; in-depth field notes were constructed after observations.

*Interviews.* After the observations, 69 hours of in-depth, semistructured interviews (Hesse-Biber, 2006) with 28 patients (8–10 per facility) were conducted regarding IBs and the role of the facility environment. Patients were selected to capture varied levels of interaction with other patients in the facilities. Interviews, conducted during dialysis, averaged 2 hours and 28 minutes, were audiorecorded, and transcribed verbatim, and concluded once saturation was achieved.

### *Data Analysis*

Two research team members reviewed several field notes and interview transcripts and discussed emergent patterns to develop a codebook including inductive, structural, and provisional deductive codes (Saldaña, 2013). Deductive codes were based on: (i) categories of prior research on the informational dynamics of social groups in everyday life (information access, flow, and acceptance) and (ii) objects, spaces, and bodies as units of analysis. Field notes and interview transcripts were analyzed in first-round coding using NVivo software (QSR International, Burlington, MA). Data were coded by two coders; interrater reliability was excellent (Cohen's K = 0.77) (Landis & Koch, 1977). Second- and third-round coding involved pattern coding (Saldaña, 2013) and mapping codes onto Boell and Cecez-Kecmanovic's (2010, 2011) sociomaterial extension of Stamper's (1991) model, respectively. Analytical memos explored emergent patterns throughout.

TABLE 1. Characteristics of dialysis facilities ($n$ = 3).

| Characteristics | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| Geographic type | Suburban | Urban | Rural |
| Profit status | Nonprofit | For-profit | Nonprofit |
| Number of patients | 172 | 109 | 121 |
| Number of staff | 25 | 17 | 18 |
| Number of stations | 16 | 20 | 17 |

## Results

### *Description of Study Sites and Individual Participants*

The facilities were located in diverse geographic settings (Table 1). The number of chairs per site ranged from 16–20, the number of patients from 109–172, and the number of staff members from 17–25.

The mean age of interviewees was 67.1. Two-thirds were white (67.9%); just over half (53.6%) were male (Table 2). Few had a college/professional degree (10.7%).

### *Physical World*

This layer relates to physical carriers of information; hemodialysis facilities have characteristic arrays of objects, bodies, and uses of space that shape IEs as persistent information carriers and as facilitators/barriers to interaction with physical information carriers such as screens and other people within them (see Table 3).

### *The Role of OSB*

*Objects.* Hemodialysis replaces renal function by cleaning blood and removing excess fluid. Patients were hooked up to dialysis machines through an "access" in their body, which allowed soft tubes to be connected to remove and replace blood. Screens on hemodialysis machines showed ongoing treatment status. Additional equipment and instruments assessed patients' status: blood pressure cuffs, thermometers, and scales. Objects such as health records also recorded status and progress; education documents and posters provided information. Patients brought objects from home, such as iPods, and shared items like puzzles, left in the waiting room in the rural facility (see Figure 3).

TABLE 2. Interview participant characteristics ($n$ = 28).

| | Site 1 (Suburban) | | Site 2 (Urban) | | Site 3 (Rural) | | Total | |
|---|---|---|---|---|---|---|---|---|
| Characteristics | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| Gender | | | | | | | | |
| Male | 4 | 50% | 5 | 50% | 6 | 60% | 15 | 53.6% |
| Female | 4 | 50% | 5 | 50% | 4 | 40% | 13 | 46.4% |
| Age | | | | | | | | |
| Mean | 67.3 | | 63 | | 70.7 | | 67.1 | |
| Race | | | | | | | | |
| White | 3 | 37.5% | 7 | 70% | 9 | 90% | 19 | 67.9% |
| African American | 4 | 50% | 3 | 30% | 1 | 10% | 8 | 28.6% |
| Asian/Pacific Islander | 1 | 12.5% | 0 | 0% | 0 | 0% | 1 | 3.6% |
| Native American | 0 | 0% | 1 | 10% | 0 | 0% | 1 | 3.6% |
| Education | | | | | | | | |
| Grades 9–12, no Diploma | 1 | 12.5% | 2 | 20% | 0 | 0% | 3 | 10.7% |
| High school Graduate/GED | 2 | 25% | 3 | 30% | 6 | 60% | 11 | 39.3% |
| Vocational school or some college | 3 | 37.5% | 3 | 30% | 4 | 40% | 10 | 35.7% |
| College degree | 1 | 12.5% | 2 | 20% | 0 | 0% | 3 | 10.7% |


DOI: 10.1002/asi

TABLE 3. Apprehensibility of information produced by objects for patients.

| Bodily phenomena | Instrument used | Information objects | Apprehensibility |
|---|---|---|---|
| ***More Apprehensible to Patients (requiring less clinician intervention to perceive structure)*** | | | |
| General symptoms (for example, fatigue, pain) | Electronic Health Record (EHR) | Data concerning symptom, severity, duration, start time | • Patients sense, report to staff |
| Treatment time | Dialysis Machine | Machine shows time spent, time remaining | • Patients can track time on machine, often not visible due to placement<br>• Staff tell patients remaining time |
| Weight | Scale | Interdialytic weight gain | • Patients see scale<br>• Patients told by staff<br>• Symptoms if high |
| Temperature | Thermometer | Degrees of body temperature | • Patients see thermometer<br>• Patients told by staff<br>• Symptoms if high |
| Blood pressure | Blood pressure cuff | Systolic and diastolic blood pressure measures | • Patients see cuff<br>• Patients told by staff<br>• Symptoms if very low |
| Medications | EHR | Data regarding prescriptions and administration | • Prescriptions generated by staff<br>• Records of in-center drug administration<br>• Medication bottles brought to facility by patient for medication reconciliation<br>• Patients' notification of drugs taken |
| ***Less Apprehensible to Patients (requiring more clinician intervention to perceive structure)*** | | | |
| Fluid volume overload | EHR<br>Stethoscope | Data concerning presence, description, severity of signs | • Staff examine ankles, back, lung sounds<br>• Symptoms if high (but may not be sensed) |
| Serum phosphorous | Laboratory tests | Grams/deciliter of blood | • Dietician explains laboratory report<br>• Symptoms if outside range (but may not be sensed) |
| Clearance of toxins from blood | Laboratory tests | Kt/V or urea reduction ratio | • Dietician explains laboratory report<br>• Symptoms if outside range (but may not be sensed) |

FIG. 2. Dialysis room, showing chairs, dialysis machines, and personal televisions. [Color figure can be viewed at wileyonlinelibrary.com]


DOI: 10.1002/asi

FIG. 3. Facility waiting room, showing chairs, television, posters on walls, and puzzle. [Color figure can be viewed at wileyonlinelibrary.com]

*Spaces.* Facilities provided therapy in large rooms with multiple patients, each occupying a recliner next to a hemodialysis machine that faced staff and a personal television (see Figure 2). Patients often waited in a waiting room before treatment. Due to insurance reimbursement patterns, hemodialysis occurred on rigid, thrice-weekly schedules; patients had shifts in the morning or afternoon, and on Monday/Wednesday/Friday or Tuesday/Thursday/Saturday.

Each session, patients had contact with clinicians, especially patient care technicians (PCTs) and nurses, who oversaw multiple patients. Staff made regular rounds, passing each chair. This provided physical closeness often followed by conversation. Other staff, such as physicians, social workers, and dieticians, visited patients' chairs more intermittently.

Patients with adjacent shifts saw one another repeatedly, often in the waiting room (see Figure 3). However, interactions with other patients were limited, partly due to spaced-out dialysis stations separated by equipment and facing outwards (Figure 2).

*Bodies.* Once connected to a machine, patients had to keep still or trigger an alarm, which could lengthen their session:

> *I get to waving this arm around and the machine quits … it adds more time on the end … so you behave yourself.*

Being tethered could be frustrating: "*Sitting in this [chair] is really hard … I sit a lot at home, but you have that freedom to get up and do whatever.*" It also meant relying on staff for ice (often desired by patients due to its ability to be consumed more slowly than water, thus helping them follow their fluid restrictions) or help reaching belongings.

### *Information Behavior*

*Information access.* Information-carrying objects were prerequisites to access (Stamper, 1991). Ongoing proximity to clinicians meant patients typically perceived health information as readily accessible: "*I have access [to information] … there's always a couple nurses here… .*"

*Information flow.* The physical world also constrained information flow. Patients had to request that their machine be turned towards them rather than staff. Equipment impeded conversation: "*…you've got a machine in the way … we're really compartmentalized… .*" Patients also found it difficult to engage in IB with physical information carriers/senders requiring hand or arm movements, such as typing or reading: "*…I used to bring a newspaper … [b]ut one day … This (pointing to one of the dialysis lines) maybe I moved in a way, it popped out … Shot blood all across the building … [now] I keep my arm straight.*"

*Information acceptance.* Ongoing contact meant patients developed relationships with clinicians; these could be marked by warmth and made some patients trust the information they provided: "*All of the doctors and techs … there's nothing I would be afraid to ask them … and nothing they wouldn't answer honestly.*" Additionally, ongoing experience allowed patients to form opinions about staff competence and expertise, which often facilitated information acceptance: "*He's an expert … I put my health in their hands.*"


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### *Empirics*

The empirical layer addresses the ability to distinguish "information" from "background noise" and shapes the ways in which patients select information "from the available physical phenomena" (Stamper, 1991, p. 517), ensuring "successful transmission" of information (Boell & Cecez-Kecmanovic, 2010). The physical world is thus where empiric phenomena take place (Boell & Cecez-Kecmanovic, 2010). When a signal cannot be recognized, it cannot contain information (Boell & Cecez-Kecmanovic, 2010). In an IE, the extent to which information cannot successfully be transmitted is of import. In order to ensure successful information transmission, ensuring adequate "channel capacity" and messages redundancy are notable strategies, both of which have corollaries in dialysis facility IEs.

### *The Role of OSB*

Objects

All three clinics had significant ambient noise generated by persistent resident objects: dialysis machines, televisions, and door buzzers. One major source was dialysis machine alarms. One interview was interrupted by a very loud alarm:

> *Interviewer: "…that alarm, when that goes off, that is so loud. (both laugh) …does that happen very often…?"*
>
> *Patient: "Oh, at least once [each session]. I don't even know what that alarm's for."*

Televisions also generated noise; patients and visitors complained when they were particularly loud.

The thermostat and dialysis machine also endured across time and space, chilling many patients on a recurrent basis. Some brought blankets but most commented that they had to just "grin and bear it." Excessively bright ceiling lights also caused discomfort.

*Spaces.* Dialysis embeds patients in a recurring process and stable spatial context. Clinicians repeatedly visited chairside to perform procedures and assessments.

*Bodies.* Patients' bodies returned to dialysis over and over, and they often felt uncomfortable or ill while dialyzing. Many suffered from sitting for hours, or symptoms such as fatigue or cramping. For example, during observation sessions, patients were regularly observed complaining of cramping during their sessions, as occurred in this fieldnote in which a patient complained to a nurse "*…my leg is really hurting … [i]t's like there's a big shot of pain coming up, and it's bad…* ."

Moreover, hemodialysis caused emotional turbulence, with initiation being especially difficult. New patients expressed fear: "*I was scared of … scared of everything, the whole concept.*" For others, beginning dialysis sparked sadness, anger, or confusion.

### *Information Behavior*

*Information access.* Noise constrained access by making it difficult to discern messages; in what can be understood as an effort to increase channel capacity, patients regularly asked staff to repeat themselves. This patient explained his efforts to successfully receive information despite the constraints: "*…there is a noise level … sometimes I can hear people clearly, sometimes I can't. [DoctorName], for some reason, he wants to step a little farther back and tell me stuff, and I got to say … 'Doc, come in closer.'*"

However, not all patients acted to increase channel capacity. Some patients chose not to talk to other patients: "*I'll holler at [another patient] once in a while. But it's too noisy.*" Noise caused patients to withdraw through headphones or sleep, limiting information access, and one took medication: "*…you get that Benadryl, next thing you know … you wake up … and you're feeling good because you had something to do instead of listen to alarms…* ."

Cold and lighting prompted huddling under blankets, or closing one's eyes: "*…if my eyes are hurting because of this lighting … I shut my eyes.*"

*Information flow.* Clinicians' comings and goings facilitated information flow via routine redundancies, which helped patients discern information. Ad-hoc communication was often initiated by clinicians in response to problems, and often reinforced prior messages. For example, staff took cramping as an opportunity to repeat fluid restrictions: "*…when I first started, my fluids … would be off … [now] I know … how much … to drink. …here on the machine … they told me about the fluids.*" Repetition was also accomplished through sharing documents, as this patient noted that the dietitian "*…comes by periodically with a list of things that, you know, you can eat this but not that. And that helps.*" Patients also asked questions during such contact, and some described clinicians' efforts to increase channel capacity and overcome noise to facilitate successful communication of information. As this patient said, "*…the techs usually talk kind of loud … and so do the nurses…* ."

*Information acceptance.* Physical discomfort and emotional challenges could constrain information acceptance. For example, some patients described having "information dumped on" them or being "inundated." Another patient said, "*I didn't want to hear all the different ways … you could dialyze. That scared me.*" As patients became more familiar with dialysis, some became more accepting of information.

### *Syntactics*

Syntactics concern whether and how information is apprehensible. Apprehension is facilitated by formal structures, or rules and principles, inherent in representations, including data, records, language, tables, figures, and calculations (Boell & Cecez-Kecmanovic, 2010). At this level, we examine whether


DOI: 10.1002/asi

information is presented using a syntax that recipients collectively understand (Boell & Cecez-Kecmanovic, 2010).

### *The Role of OSB*

*Objects.* Data and records assigned formal structure to information about the patient. As Table 3 shows, when recording patients' data, medical objects read and displayed their physical states. Monthly laboratory tests also generated reports. Health status and treatment were thus converted into persistent information objects.

*Spaces.* Dialysis followed a routine recurring many times per day in a stable spatial environment. Patients and staff assumed their roles in the space in a predetermined sequence, typically without prompting. Spaces provided scaffolding for routines and instruction, as shown in fieldnotes:

> *Nurse comes into the waiting area and asks the woman to come with her into the dialysis room and get weighed. … Nurse tells woman, "The scale is the stainless steel thing in the floor on the left just inside the door."*

*Bodies.* While many physical experiences were captured as data by medical instruments, some could not be. Pain and other symptoms could only be perceived by staff if reported. Interpreting sensations required that patients understand both usual and unusual physical experiences of dialysis, and they learned to label experiences clinically. For example, this patient learned to correlate symptoms with "low blood pressure" measured by instruments: "*…my blood pressure dropped real low … you're sweating … you get a headache… .*"

### *Information Behavior*

*Information access.* Converting experiences into information objects (data, records, language) resulted in measures and concepts of variable apprehensibility (Table 3). For example, weight and blood pressure relied on common consumer instruments; patients generated these measures themselves in some facilities. Other objects, however (for example, dialysis machine displays, laboratory reports), required instruction. Similarly, apprehension of the overall care routine required repeated explanation.

*Information flow.* Gaps in apprehensibility create reliance on clinicians for instruction and are a key impetus for clinician–patient information flow. For example, this patient described learning to decipher the dialysis machine display: "*I asked different questions. They told me … the temperature and all that stuff. The hours, the minutes, and how much time you've got left… .*"

*Information acceptance.* As patients grasp the principles of clinical data, records, language, and routines, they learn to correlate them with their experiences; moreover, their experiences help them understand the structure. One said, "*…you learn more every time … you don't get all the answers [from staff] … it's just like the experience.*" Internalizing structure through experience, patients developed an embodied sense of relevance, connecting measures to their well-being:

> *The bottom line for me is, you've got to learn this machine … because that machine is going to tell you everything that's gonna happen to you. … I notice how much time I've got left … [I look at] the blood pressure. … And how much [fluid] I'm taking off… .*

## *Semantics*

The semantic layer adds meaning to the structure provided by the syntactic layer. To hold meaning, information must be integrated into prior knowledge. As we focus on here, this layer includes the determination that meanings are valid or truthful (Stamper, 1991), and thus important.

### *The Role of OSB*

*Objects.* Objects conveying clinically valid meanings were given by staff, and often came with expectations for use. Patient education was mandatory, scheduled, and accomplished via documents and multimedia. For example, patients were required to watch videos during dialysis on set topics quarterly: "*…It tell[s] you how to evacuate if something happen, how to cut the machine off… .*"

*Spaces.* The validity of information was also established through prominent, enduring positioning on bulletin boards, dialysis room doors, and waiting room walls. Locations in lines of sight demanded attention (see Figure 4).

*Bodies.* Patients assigned meaning at the semantic layer by observing the care others' bodies received: "*I … watch people and see who's getting this done and who's getting that done.*" Patients related their first-hand physical experience to what they saw in others.

### *Information Behavior*

*Information access.* Mandatory education documents had a positive impact on perceived information access: "*they give you so much information … when you come in from the training, you leave with a book.*" Materials were often in large-print or plain-language formats to maximize comprehension.

*Information flow.* Education activities involved the flow of information from clinicians, who checked understanding of materials or addressed queries about them. In the following exchange, a technician gave a patient a large-print photocopied sheet called, "Why Do I Cramp During Treatment?":

> *Technician: "Here's your teaching for this month, [PatientName]. Take a look and I'll be back in a bit to see if you understood it."*
>
> *Patient: "OK, thanks." [looks at the paper]*


DOI: 10.1002/asi

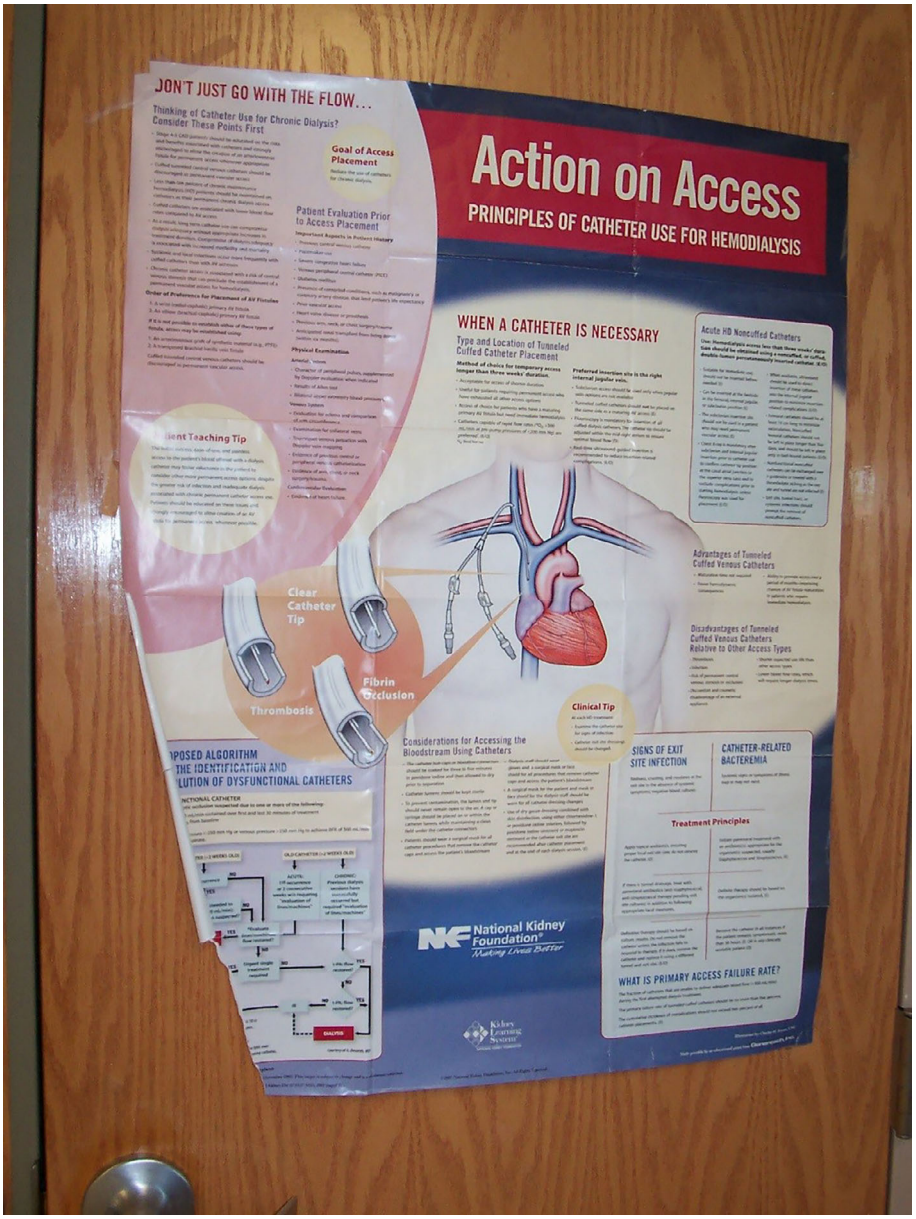


FIG. 4. Eye-level poster on dialysis room door. [Color figure can be viewed at wileyonlinelibrary.com]

Such interactions led to a common assessment: *"… they've been very good about keeping me informed."*

Notably, the flow was primarily from clinician to patient rather than patient to clinician or patient to patient. Patients did not produce displays or give providers documents. Furthermore, patients' inferences about one another were usually informed by observation rather than direct interaction; information "senders" did not necessarily participate intentionally. For instance, a patient interviewee expressed concern about a patient seated near him: "*She broke her knee … she'd talk to the tech … she used to kid her and talk to her. But now she just lies there. She don't ask for anything.*"

*Information acceptance.* Patients typically regarded information objects given by clinicians or prominently placed as valid and important: "*…they give you little lessons about once a month. … I learn through that and try to pay attention…* ."

Patients described being affected by information, which required accepting it. One said: "*…they have … something out on the bulletin board about not shortening your dialysis time. … I thought, 'Well, that's the way it is.*'" This perceived validity likely emanated from the message's "official" material format and clinical context.

### *Pragmatics*

The pragmatic layer involves "larger structures" of communication, and the purposes they fulfill (Boell & Cecez-Kecmanovic, 2010, p. 3). Pragmatic repertoires involve


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intentional communication acts, which includes interactional units such as conversations and negotiations. We focus here on interactional units that occurred with regularity, and their material grounding.

### *The Role of OSB*

*Objects.* Care planning, a recurring interactional unit, was structured around documents. Patients were given an official plan at the beginning of therapy that was verbally revisited intermittently. The document's official nature was reinforced by the requirement that patients sign to indicate agreement.

The conversational unit of "giving feedback" was also anchored by objects. Patients were provided monthly paper-based laboratory reports, which patients called "report cards," and that were occasions for monthly feedback sessions with dietitians. Giving feedback also occurred after clinicians took measurements or examined patients, as in this fieldnote involving a stethoscope:

> *Nurse [to Patient]: "They're sounding better." [about his lungs]*
>
> *Patient: "Good!"*

*Spaces.* "Rounds" were performed by physicians, nurse practitioners, or physician assistants as they moved throughout the space. Rounding was anchored by patient records, which clinicians reviewed as they visited each patient, as recorded in fieldnotes:

> *Physician looks down at his laptop for about a minute, reading. Then he moves over to stand next to Patient and Nurse follows him but stands on the other side of the patient. Physician and Patient talk quietly…*

*Bodies.* Although patients' bodies were always present during their care, their physical states changed continually. Staff only knew of symptoms or events at home through interactions with patients. Accordingly, they regularly engaged in the interactional unit of "check-ins," which were grounded in awareness of the patients' body. Nurses asked standard questions at the beginning of treatment, as shown in fieldnotes:

> *Nurse goes over to Patient at station 10. They greet each other briefly, with Patient saying he's feeling tired today.*
>
> *Nurse: "Any shortness of breath, chest pains or anything?"*
>
> *Patient: "Nothing more than usual. Just some shortness of breath like usual."*
>
> *Nurse: "OK."*

Check-ins took place when connecting and disconnecting from the machine, and at 30-minute checks and weigh-ins.

### *Information Behavior*

*Information access.* The materially-grounded interactional units of care planning and rounds ensured regular patient access to personalized clinical information. However, they also introduced constraints, since clinicians controlled the pace. Sometimes patients felt clinicians were too busy to answer questions: "*They have too much to do.*" Some felt rushed: "*You've got to catch him fast if you want to say something because he's really in a hurry… .*"

*Information flow.* Care planning, feedback, clinicians' rounds, and check-ins all facilitated information flow between clinicians and patients, and vice versa. This vignette from study fieldnotes illustrates information given to the patient during the interactional unit of care planning:

> *Nurse: "[PatientName], this is your plan of care. I need you to sign it right here."*
>
> *Patient: "What's this?"*
>
> *Nurse [a little louder]: "This is your plan of care that you need to sign." [puts the clipboard on the center counter, and Patient turns her chair back around and walks/wheels over; they look through it together while Nurse talks through it, pointing at different parts of the pages as she does]*
>
> *Nurse: "Your dry weight is 110 kilograms. Let's see…" [pause] "We want to try to decrease your fluid gains. Your hemoglobin is good. We want to encourage you to eat more protein." [pause] "Your albumin is 4.1, we like it to be over 4.0, so that's good." … This one here is the social worker. "A little depression, he says, and you're in treatment." … "And that's it." [hands patient a pen and points]*
>
> *[Patient signs where indicated]*

*Information acceptance.* The interactional unit of giving feedback influenced how information was received. Feedback told patients whether values were considered good or bad in general, and for them, specifically. Staff helped patients interpret indicators by volunteering information or in response to queries, as fieldnotes show:

> *Patient: "How is my fluid level?"*
>
> *Technician: "Beautiful."*
>
> *Patient: "Oh, that's wonderful. What's the number?"*
>
> *Technician: "6.6"*
>
> *Patient: "That's good, right?"*
>
> *Technician: "For you, that's beautiful!"*

Over time, patients prioritized good/bad numbers, making adjustments to get good "report cards." One said, "*I eat exactly what these people want me to eat. … I have to … get that good report card.*"


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### *Social World*

The social world refers to "relations between people, their mutual commitments, [and] mutual expectations, including both the cultural and the explicit norms that govern their behavior" (Stamper, 1991, p. 519). Accordingly, this section examines mutual commitments and norms in study facilities, and the role of physical materials in their formation and expression.

### *The Role of OSB*

*Objects.* Patients recognized that survival depended upon dialysis and voiced significant commitments to it: "*…it's a hard lifestyle, but … I want to live … I want to continue to adhere to it as much as I can.*" Another said: "*I feel like it's something I got to do … it's my lifeline.*" Belief in its necessity was accompanied by a commitment to "make the best of" it: "*You just accept what it is.*"

This commitment was expressed partly by bringing objects that helped patients tolerate dialysis, like snacks, pillows, and blankets. One brought treasured, comforting items: "*…a little soft pillow that goes behind my head … a brown blanket that … my granddaughter made that's got bears and wolves … on it.*"

Objects such as needlepoint, books or magazines, or music players facilitated escapism—"*I've always got the iPod on … it helps block [dialysis] out*"—as did television. One patient joked, "*…the worst part of [dialysis] is [watching] American daytime television for four hours.*"

*Spaces.* Patients often experienced being "alone together" with fellow dialysis patients. Most interactions were friendly but brief: "hello, goodbye, people." These interactional norms were rooted in features of the space.

The layout of the dialysis room stood in the way of further acquaintance: "*…when someone is sitting across from you or way down the other end, it's hard to … make … contact.*" Layout also prevented meeting in the first place; one patient said she only met another who dialyzed at the same time when they encountered one another at the regional transplant clinic: "*We ran into each other over there. … She was on this side, and I was on the other side, and we had not met… (laughs)*".

Interactions took place primarily in the lobby or when passing one another in the dialysis room: "*You can't talk … if they're over there … but you catch them outside in the lobby… .*"

For some, these brief interactions were satisfactory: "*I didn't come here to make friends. I came here to get clean.*" Others desired more social interaction but recognized the difficulties.

*Bodies.* Patients often saw one another struggling or in pain. However, there was a norm that people would not press others to talk about their physical states: "*…if I notice that they don't look good, I'll ask 'em if they're having a bad day … but, try to give 'em their privacy too… .*" There was also an understanding that health could be a sensitive matter, and patients avoided asking prying questions such as why others were on dialysis: "*I haven't never asked anyone why they are here … some folks get an attitude if you ask about their medical problems.*"

Physical states could also limit interaction; patients gave one another space as needed: "*…sometimes he'll stop here and if he feels good or whatever and we'll talk a little bit, but usually not a whole lot.*" One patient explained the impediments to interaction: "*Some of them … are not totally with it … others are in such pain … that they're more preoccupied.*" Patients tried not to "bother" others they could tell were not feeling well.

Banter about physical discomfort and indignities was common. Staff joked that they enjoyed inserting needles into patients, or pretended to blame them for low blood pressure. Among themselves, patients joked about experiences such as having to use the restroom while in the chair or waiting in lines, as shown in fieldnotes:

> *Patient1 is weighing himself.*
>
> *Patient2: "You mean I've gotta wait until [Patient1] is done?" [teasing tone, laughing]*
>
> *Patient1: [laughing] "Probably all the rest of your life."*

### *Information Behavior*

*Information access.* The "alone together" norm of dialysis impeded access to information, especially between patients. Small talk reflected boundaries of acceptable conversation, which often steered clear of health-related matters: "*…we just talk. We don't talk about … dialysis or anything.*" One patient did not talk to others about dialysis because "*…[t]he subject don't ever come up.*" Another said, "*We don't always got to talk about dialysis, right? … it's a headache for me, I know it's a headache for you. So, let's talk about something different… .*"

Privacy norms and efforts to give one another space as well as banter led to many missed opportunities for patient information sharing.

*Information flow.* As an expression of the mutual commitment to tolerate dialysis, patients occasionally exchanged information about making dialysis more comfortable, at times prompted by seeing personal possessions. For example, patients spoke about how many blankets they needed to feel warm. As this fieldnote shows, others reached out unprompted:

> *…she rummages in her tote bag and pulls out a bag of Tootsie Pops. She walks … to the other patient … and offers a couple. She talks about how Tootsie Pops help her deal with dry mouth and thirst while dialyzing.*

Staff also instructed patients in object-focused strategies that might help them, as this fieldnote shows: "*You can watch TV while you're here, listen to music… .*"


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*Information acceptance.* The collective commitment to "make the best of" dialysis meant many accepted clinical information without question: one said he never asked why he could not have ice: "*…against the rules or something. … I don't question that. … Go with the flow.*" Information was valued corporeally, if it helped one feel better: "*I listen to everything … that's going to help me out in the long run.*"

Patients who valued experiential information from other patients were the minority. Patients typically preferred obtaining information from clinicians: "*I figure I should talk to somebody that knows what they're talking about.*" A similar point of view was expressed by this patient:

> *He says he wouldn't want to get information from other patients: "What do they know?" He says he always goes straight to someone official, like a nurse, doctor, or social worker.*

## Discussion

This study showed that OSB contributed to each sociomaterial layer of facility IEs. At the physical layer, they served as carriers of information, and proximity facilitated positive perceptions of access; however, constraints such as immobility prevented some IB. The ability to detect information (empirical layer) was impeded by noise, cold, lighting, and physical/emotional discomfort; yet repetition and efforts to increase channel capacity by moving closer or speaking louder ensured some information was received. The principles contained in clinical data, language, records, and care routines (syntactic layer) varied in apprehensibility; however, clinician instruction partly countered this. Understanding these structures helped patients assign relevance to information. At the semantic layer, transfer and display of paper documents communicated information value, facilitating information flow and acceptance. At the pragmatic layer, interactional units of care planning, feedback, rounds, and check-ins were all materially grounded in OSB. They ensured regular access to information, and patients learned criteria for judging information such as blood pressure. Finally, OSB helped shape a social world comprised of norms and mutual expectations in which comfort and escapism were sought, bodily humor reduced tension, and patients connected on a surface level, often avoiding opportunities to exchange information concerning health.

### *Sociomateriality and Patient Roles in IEs*

Patients can be mutual sources of experiential information, especially practical strategies and personal stories regarding illness-related management and adaptation (Veinot, 2010). However, in facility IEs, enduring material layers combined to construct patients primarily as passive recipients of information rather than active seekers and producers, in patient–clinician interaction and especially between patients. This resonates with research arguing that inequalities between clinicians and patients may be embedded in healthcare facility design (Brandt & Sloane, 1999). Material constraints included the orientation of dialysis machines towards staff, and distance and visual barriers between dialysis chairs. Immobility was also a barrier to IB; correspondingly, feeling confined may reduce patient self-disclosure (Okken, van Rompay, & Pruyn, 2012).

### *Sociomateriality and Information Access*

Spaces placed patients close to objects and staff, often through repetitive interactional units such as rounds, creating perceptions of easy access to clinician-provided information. The materiality, or enduring quality, of these IE features may have increased perceptions of consistent information access. Similarly, Taylor (1991) identifies that "perceived ease of access" to information relates to cognitive representations of a setting, including physical proximity. Findings newly highlight temporal aspects of proximity that place people together at predictable times.

The results extend previous research by showing that information access also relates to objects and bodies; for instance, facility objects introduced noise, which made information difficult to discern. Additionally, cold temperatures and harsh lighting caused patients to withdraw; this aligns with previous research showing that harsh lighting is associated with less personal disclosure (Miwa & Hanyu, 2006). Fisher (2006) notes that people consider factors such as ambient noise in determining where to exchange information. Additionally, objects such as medical instruments were typically not apprehensible, creating barriers to information; this aligns with Godbold's (2013) observations that patients discussed the inaccessibility of this information to them in online forums for dialysis patients. The enduring nature of facility spaces and arrangements of objects within them also shaped movements and activities (McCullough, 2013) as part of care routines. Psychological mechanisms for this may include priming processes (Fiedler, 2007), whereby cues in the environment activate knowledge.

### *Sociomateriality and Information Flow*

The findings revealed constraints to seeking information independent of staff, or from other patients. Clinicians facilitated information flow through repetition, instruction in medical language, and the structure of patient data, patient education, care planning, feedback, and rounds, spanning the worlds of medical treatment and everyday life. This echoes previous work on gatekeepers who span boundaries across groups (Agada, 1999; Metoyer-Duran, 1993).

The results contrast with research emphasizing the role of spatial proximity in facilitating IB. Unlike the waiting rooms described in information grounds theory (Fisher, 2005), patients experienced materially grounded norms that constrained information flow, including the "alone together" experience whereby fatigued patients mutually avoided discussing their health. Privacy expectations also kept patient discussions light and information exchange absent.


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*Sociomateriality and Information Acceptance*

Previous literature asserted that "living together in a small world" causes people to favor information provided by insiders due to a shared sense of collective relevance (Chatman, 1999) emanating from spatial proximity and shared experience. Similarly, in facility IEs, regular proximity to clinicians facilitated trust in, and reliance upon, information they provided. Additionally, per social psychological research (Fiedler, 2007), repetition of the dialysis experience helped people perceive patterns in their environments.

Extending this work, the findings demonstrated the role of the body in information acceptance, since physical experiences were correlated with care activities, clinical terms, and data points. Moreover, information was typically not questioned if it helped people feel better. Similarly, Godbold (2013) found that dialysis patients found experiences, including their sensations, to be authoritative information sources. Not discussed elsewhere, emotional challenges and feeling ill modulated information acceptance. Relatedly, human information-processing capacity diminishes under stress (Cohen, Evans, Stokols, & Krantz, 2013).

Our work newly emphasizes the roles of objects such as prominent posters in facilitating information acceptance. Furthermore, patients were given documents for education, planning, and feedback by clinicians who highlighted their value, and were often required by organizational policy to share them. This aligns with research showing that documents can exercise control and "do things" in organizations and institutions (Frohmann, 2007; Hull, 2012), including their important role in the constitution of policy (Shankar, Hakken, & Østerlund, 2017). Notably, as a material form, paper-based documents may serve institutional functions of rendering information "official" (Robertson, 2014). The transfer and highlighting of documents, and their materiality, helped patients accept them as valuable; in turn, this helps to establish what information is more or less important. Similarly, Sundin and Carlsson (2016) argue that the Google search engine, as a sociomaterial technology, helps to construct what information should be seen as significant; that is, it produces a "knowledge order."

*Catching Up to Practice: Design of IEs*

Professional information practice increasingly encompasses materiality, treating objects and spaces as matters for intervention. For example, libraries are expanding their collections to include objects such as toys and tools (Soderholm & Nolin, 2015). The design of library space has been of growing concern as large-scale building projects attempt to reassert the importance of the libraries as "places" (Buschman & Leckie, 2007). Given (2007) identifies the importance of library spaces that are "welcoming" in terms of lighting and comfort to permit longer stays, movable furniture allowing group work, and areas permitting conversation. Similarly, workplace designs newly incorporate open spaces to encourage collaboration (Hua, Loftness, Heerwagen, & Powell, 2011).

## Box 1 Sociomaterial Guidance for Designing Information Environments.

**Access**

- Objects
  - The presence of objects makes some forms of IB possible.
  - Objects that create noise or physical discomforts impede information detection.
- Spaces
  - Spatial and temporal proximity of enduring materials increase perceptions of access.
  - Control of the timing and location of interactions can influence perceptions of access.
- Bodies
  - An inability to move freely may inhibit IB.
  - Differences in mobility may create imbalances in access.

**Flow**

- Objects
  - Information contained in objects has a structure that requires expertise to discern; intermediation may be required.
  - Objects may facilitate information flow through their display and transfer, but they may also facilitate withdrawal from an IE.
- Spaces
  - Obstructed lines of sight between colocated people impede information flow.
  - The enduring arrangements of objects in space configure routine activities and associated movements of people.
- Bodies
  - Physical display, especially when one is suffering, prompts efforts to seek, or respect, personal privacy; this may impede information flow.
  - Negative physical and emotional states may impede information flow.
  - Repetition may help to successfully transmit information.

**Acceptance**

- Objects
  - Regular proximity to information sources may facilitate acceptance.
  - Documents that are discussed, signed and/or transferred are imbued with value.
- Spaces
  - Display of objects and documents in prominent and "official" locations conveys value.
  - Familiarity with emplaced routines helps to establish information relevance.
- Bodies
  - Physical experiences suggest the validity/importance of information.
  - Information that helps people feel good may be believed valid.


DOI: 10.1002/asi

Despite this, guidance for designing IEs is lacking. Building on this study's findings, we present "Sociomaterial Guidance for Designing IEs" (Box 1). This guidance builds on the sociomaterial extension of Stamper's model, while synthesizing key implications of (i) material phenomena of OSB; and (ii) IB, including constraints and enablers of access, flow, and acceptance. This guidance aims to provide initial design considerations across a variety of environments, not only healthcare spaces.

Several limitations should be kept in mind. First, the study was conducted in the United States, which differs from other countries in terms of practice patterns; these findings may not apply to all dialysis facilities. Second, dialysis patients experience more discomfort than most; bodily experiences may interfere less with IB in other groups. Third, the study focused on a small number of facilities and patients; other patterns may exist elsewhere. Nevertheless, the sample was large and diverse for a qualitative study, lending credence to the findings. Fourth, the design guidance presented here emerged from one type of IE; accordingly, they require validation in other settings.

While the extended Stamper framework affords an opportunity to empirically adopt a sociomaterial perspective, the framework does depart from strict interpretations of sociomateriality. This strict perspective asserts that the material and the social cannot be ontologically separated (Latour, 2004); in contrast, the extended Stamper framework does visually depict separation between the physical and the material through the "layer" metaphor. However, researchers have recently recognized the need to make these analytical separations in order to empirically operationalize sociomateriality (Elbanna, 2016; Mueller et al., 2012). In this way, Stamper's framework is an empirically useful tool for examining material aspects of information that would have been unnoticed without this analytical separation. Based on this study, however, we argue that the extended Stamper framework is best used as a whole, since the collective sum of these layers articulates the relational ontology underpinning the sociomaterial perspective. This holistic approach also aligns more effectively with information environments theory, which casts analytical attention on social groups in context rather than individuals alone.

## Conclusion

This study demonstrates the sociomateriality of IEs, and that OSB play key roles at multiple sociomaterial layers of IEs. Moreover, we showed that sociomaterial layers shape IB within them, with a particular focus on access, flow, and acceptance. This extends IE theory, while more deeply contextualizing group-level IB. A sociomaterial perspective and related focus on OSB offers a lens for information practice; we contribute preliminary IE design guidance to facilitate such practice. We also stress that the value of certain sources and types of information can be materially encoded in an IE. This was evident in the valuing of clinical information over information from patients, which emerged partly from material constraints. Accordingly, we caution IE designers to explicitly consider power issues, particularly sociomaterial construction of information recipients, seekers, and producers when designing IEs.

## Acknowledgments

Funding was provided via NIH grant #UL1RR024986.

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DOI: 10.1002/asi