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Original Contribution

An Ecological Perspective on Medical Care: Environmental, Occupational, and Public Health Impacts of Medical Supply and Pharmaceutical Chains

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Abstract: Healthcare organizations are increasingly examining the impacts of their facilities and operations on the natural environment, their workers, and the broader community, but the ecological impacts of specific healthcare services provided within these institutions have not been assessed. This paper provides a qualitative assessment of healthcare practices that takes into account the life-cycle impacts of a variety of materials used in typical medical care. We conducted an ethnographic study of three medical inpatient units: a conventional cancer ward, palliative care unit, and a hospice center. Participant observations (73 participants) of healthcare and support staff including physicians, nurses, housekeepers, and administrators were made to inventory materials and document practices used in patient care. Semi-structured interviews provided insight into common practices. We identified three major domains that highlight the cumulative environmental, occupational health, and public health impacts of medical supplies and pharmaceuticals used at our research sites: (1) medical supply procurement; (2) generation, handling, and disposal of medical waste; and (3) pharmaceutical handling and disposal. Impacts discovered through ethnographic inquiry included occupational exposures to chemotherapy and infectious waste, and public health exposures to pharmaceutical waste. This study provides new insight into the environmental, occupational, and public health impacts resulting from medical practices. In many cases, the lack of clear guidance and regulations regarding environmental impacts contributed to elevated harms to the natural environment, workers, and the broader community.

Keywords: environmental justice, ethnography, medical practices, occupational health exposures, public health, qualitative methods

Introduction

Over the past decade, healthcare organizations around the world have begun to examine the ecological impacts of their facilities and operations. Many of these organizations have recognized the role they play in several major environmental and public health challenges and have begun to mitigate their impacts. For example, a number of hospitals are taking steps to curb their use of fossil fuels to decrease their impact on climate change (National Health Service 2009; World Health Organization and Health Care

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Without Harm 2009), and several healthcare organizations have replaced toxins such as mercury with safer alternatives (HCWH 2007). While these steps are helping to reduce the environmental and public health impacts of healthcare facilities and operations, the impacts that result from clinical practices related to medical supply and pharmaceutical use and disposal are poorly understood. However, such practices also warrant examination since they incur environmental and human health impacts through the manufacture, transport, and disposal of the thousands of medical supplies and pharmaceutical products used in patient care (Jameton and Pierce 2001).

As part of a larger study investigating the impacts of the materially-intensive nature of clinical care on the natural environment, occupational health, and public health, this paper describes the consequences of medical supply and pharmaceutical use and disposal in three healthcare settings. We report a range of impacts that resulted from the common clinical practices we observed at the patient bedside (i.e., point-of-care) and downstream via waste disposal. We also describe the difficulties of investigating the effects of natural resource extraction, manufacturing, processing, and transport of materials that occur upstream of the point-of-care. This paper provides a qualitative assessment of a broad range of cradle-to-grave environmental and human health impacts related to material supply chains that accumulate through clinical practices. Such information is crucial to better understanding how the healthcare industry affects the health and well-being of individuals, communities, and ecosystems beyond the hospital walls.

In the only qualitative cradle-to-grave analysis of medical supplies to date that we are aware of, Pierce and Kirby (1999) performed an "ethical life-cycle analysis" to examine the impacts of latex medical exam gloves on the natural environment and the health of workers and communities along the commodity chain. The authors described how upstream latex extraction and manufacturing processes, and downstream disposal via landfill or incineration led to environmental degradation and human health concerns. Other qualitative studies have similarly offered valuable insights into the life-cycle impacts of medical materials (e.g., mercury; Eagan and Kaiser 2002), but each of these studies has focused on the impacts of single commodities or pollutants. As a result, the cumulative impacts of typical healthcare practices that utilize multiple materials and supplies simultaneously are poorly understood.

To address this gap, this study employs qualitative methods to characterize ecological impacts of healthcare delivery that result from the simultaneous practice of multiple healthcare processes. Our approach considers healthcare institutions as complex organizations characterized by interlocking webs of supply and disposal chains, all operating simultaneously and all influenced by numerous cultural and political economic governance factors. In this way we take a holistic approach to analyzing the complex, multilevel impacts of pharmaceutical and medical supply chains.

Our work sheds light on the ways medical care touches the lives of people and places both within and beyond the walls of the hospital, showing how workers and communities are invisibly connected to healthcare operations through supply chains, clinical care delivery, and waste disposal processes. Through such connections, healthcare delivery may be seen as an ecological act.

The Setting

This paper focuses on the aggregated environmental, occupational health, and public health impacts of clinical practices in three end-of-life healthcare settings: a conventional cancer ward, a palliative care ward, and an inpatient hospice unit. End-of-life medical care for cancer patients is an opportune setting for characterizing the general environmental and human health impacts of clinical care for three reasons. First, end-of-life medical care represents an extreme example of a high cost, materially-intensive model of care that accounts for up to 18% of a person's lifetime medical expenditures (Fries et al. 1996). As such, end-of-life medical care interventions—diagnostics, pharmaceuticals, hospitalizations—rely heavily upon natural resources. Second, cancer is the second leading cause of mortality in the U.S., causing an average of 1,500 deaths per day (American Cancer Society 2010). As a result, end-of-life cancer care has potentially large cumulative environmental, occupational health, and public health impacts simply because of the number of patients requiring medical care. Finally, three end-of-life cancer medical models—conventional care, palliative care, and hospice—each differ with respect to material intervention utilization which offers an opportunity for comparative analysis, which we report elsewhere. However, through our observations and interviews regarding practices occurring upstream, at the point-of-care, and downstream from these medical settings, we discovered that care in all three settings

carries substantial impacts on human health and the environment which are generalizable to other healthcare settings. In addition, our qualitative approach provides a framework for assessing the way large-scale organizations or institutions (e.g., hospitals, schools, prisons) affect environmental quality. It also provides a baseline method for more finely-grained analyses comparing the environmental impacts of different kinds of organizations within those broader institutions.

Methods

We present data on medical practices and resource use gathered through ethnographic observations and interviews. Ethnography is a method of qualitative research that has become increasingly valuable in environmental health research (Brown 2003; Scammell 2010). In comparison to quantitative studies which offer a numerical approach for testing theories, qualitative research helps to generate theories by providing rich descriptions of the meanings people place on environmental health phenomena, and the patterns of how people experience these events (Brown 2012). In this way, qualitative methods provide broad insight on environmental and human health challenges that create the backbone for both quantitative study and for points of intervention. Qualitative methods also provide a critically-important in-depth understanding of the experiences of communities, which may be invisible in other modes of research (Savage 2000).

Research Sites

This study examines common medical practices on three inpatient units (conventional cancer ward, ~30 private patient rooms; palliative care unit, ~10 private rooms; inpatient hospice center, ~30 private rooms), and characterizes the range of impacts that may result from material flows of medical supplies and pharmaceuticals. The three medical units were selected because clinical staff members at each site were trained to provide end-of-life care, and each provided care to cancer patients at end-of-life. The conventional and palliative care units were both located within a teaching hospital in a Midwestern city; the hospice inpatient unit was within a stand-alone facility run by a non-profit organization in the same city. To investigate impacts upstream and downstream of the point-of-care, we gathered information from staff at the participating units about other institutions in the supply and disposal chains. We visited these sites in person when possible (i.e., located within the same city as the medical units), or contacted via phone when site visits were not possible (e.g., hazardous waste facilities located in another state). Upstream sites included on-site central supply storage rooms (visited), and medical exam glove manufacturing facilities (phone contact). Downstream sites included on-site waste facilities (visited), on-site reprocessing facilities (visited), infectious waste processing facility (visited), and hazardous/pharmaceutical waste facilities (phone contact). We also attended monthly product evaluation and selection committee meetings where we observed how administrators and staff members in each participating unit selected medical supplies to purchase.

This study was reviewed and approved by the Institutional Review Board of the University of Wisconsin, and administrators at both the hospital and hospice organization granted written permission to conduct the study. Participants (physicians, nurses, housekeepers, administrative staff, and waste handlers; 73 total) provided written informed consent before entering the study. Patients provided verbal consent to allow the researcher to shadow participating staff members within their rooms. Data were collected while observing the care of 56 conventional cancer patients, 21 palliative care patients, and 56 hospice patients.

Data Collection

We used two common ethnographic methods to collect qualitative data: participant observation and semi-structured interviews. A single field researcher gathered observational data over 255 hours from May 2008 to June 2009. Observations were made at each site in two rounds of approximately two months each; the first two months were spent on the conventional unit, the next on the palliative care unit, and the next at hospice and so on. This allowed us to gather extensive information at each site, while also being able to revisit each site for further observation after collecting data at all three sites.

When recruiting participants to the study, we told staff members that the goal of the study was to better understand the environmental outcomes of clinical resource use. Our informed consent forms stated, "Material resource use within healthcare has potential impacts on the natural environment, yet only limited research has explored the connections between healthcare resource use and environmental outcomes. Therefore, the purpose of this

research is to better understand the connection between the flow of resources through a number of healthcare settings and the environment.'' Clinical observations were made while shadowing physicians, nurses, housekeepers, and administrators. We shadowed medical staff for up to eight hours a day, and made observations on all days of the week and all shifts (day, evening, and night). The majority of observations occurred during the day shift Monday through Friday because this is when the most physician rounds and patient–physician consultations occur, and consequently is when most decisions regarding resource use are made.

Thirty-three hours of interviews with 36 participants (approximately 30–90 min in length) were audio-recorded, transcribed, and coded for analysis (Miles and Huberman 1994). Two objectives guided our purposeful selection of interviewees: (1) to maximize the breadth of clinical perspectives related to clinical resource use and their related environmental and health consequences, and (2) to provide clarification on topics for which we required additional explanation. We interviewed physicians, nurses, housekeepers, and other inpatient support staff, and also spoke with medical supply manufacturing personnel and waste handlers identified by administrative staff at each research site. Semi-structured interview questions inquired about common material resources used in each site, participant knowledge and concern over environmental and human health effects of clinical resource use, differences and similarities in end-of-life care models, and factors that govern resource use decision-making (i.e., political economy, cultural norms, etc.). Unreferenced quotations are drawn directly from interview transcripts.

Results and Discussion

We identified three major categories of routine healthcare operations related to environmental, occupational, and public health impacts at our three research sites: medical supply procurement; generation, handling, and disposal of medical waste; and pharmaceutical handling and disposal. We organize our analysis around these three domains because they are managed by different actors and these categories allow us to clearly identify points of intervention for mitigating their impacts. In addition, we analyze the level of staff concern regarding environmental and health concerns to show how these concerns are prioritized within the healthcare arena.

Medical Supply Procurement

We identified a lack of standardized environmentally preferable purchasing (EPP) programs at our research sites as a routine healthcare operation associated with a number of environmental and human health consequences.

Many hospitals have begun to employ EPP to procure medical supplies, products, and services whose life-cycle environmental impacts have been studied and found to be smaller than the impacts of standard products (Practice Greenhealth 2011). At the time of this research, none of the medical facilities included in this study subscribed to EPP practices. Furthermore, the purchasing administrators we interviewed at each of our sites who worked directly with institutional committees that oversaw product evaluation and selection were unaware that EPP options existed. Medical supply purchasing decisions at both institutions were made based upon two factors: ''First and foremost any item has to be clinically acceptable… then we tend to pit all the clinically acceptable items against each other to determine which is more financially advantageous to us.'' Environmental and human health concerns were not a standard consideration in purchasing decisions at any of our three sites. This lack of using EPP as standard practice shows that our research sites had not committed to using products that were the safest known options available for protecting the environment and human health. Furthermore, this lack of EPP prompted us to investigate the life-cycle impacts of alternative products through which we discovered a number of broader challenges to minimizing the consequences of medical supply chains.

At the time of our observations, our research sites were considering replacing latex medical exam gloves with nitrile gloves. The hospital had already increased their use of nitrile gloves to about 60% of glove use, but an increase in the global cost of latex was making the possibility of a latex-free institution more economically feasible. We decided to investigate the life-cycle environmental, occupational, and public health impacts of nitrile by replicating Pierce and Kirby's (1999) ''ethical life-cycle analysis'' of latex gloves, as discussed above. Interviews with purchasing administrators informed us that the hospital purchased all of its nitrile gloves (about 7.8 million annually) from a single vendor who manufactured and distributed the gloves. We contacted the vendor to learn more about the upstream nitrile glove supply chain and any known environmental and public health concerns. Our two U.S.-based phone contacts (one infection control consultant knowledgeable about the

properties of nitrile gloves, one technician knowledgeable about nitrile manufacturing) informed us that all of the company's gloves are made in Malaysia, but we were unable to get contact information for personnel further upstream. However, we were able to learn about the basic nitrile manufacturing process which allowed us to characterize the kinds of environmental and occupational health impacts occurring upstream, and the places they are likely to occur. This approach, which likely underestimates the extent of upstream impacts, points to the range of impacts occurring through manufacturing, and suggests areas for future study.

Nitrile is a synthetic rubber comprised of two main chemicals (acrylonitrile and 1,3-butadiene), and because of the impermeability of the material, nitrile gloves have become the ''gold standard'' for protecting healthcare workers from pathogens and chemicals such as chemotherapy. Both acrylonitrile and 1,3-butadiene are petroleum-derived chemicals. As such they are linked to the environmental degradation and social justice issues of oil fields (Kimmerling 1994). In addition, being manufactured in Malaysia and distributed globally, nitrile gloves have impacts related to emissions from long-distance transport (Akimoto 2003) and the environmental and health impacts of climate change (Patz 2005). Within the natural and synthetic rubber industries, occupational health and safety are of major concern and several studies have shown that industry workers have increased incidence of several cancers (bladder, haemotopoietic, lung, and stomach, in particular) from long-term chemical exposures (Chaiear 2001). Acrylonitrile is converted to cyanide within the body, and causes respiratory irritation and depression of the central nervous system in humans (National Pollutant Inventory 2010a). The International Agency for Research on Cancer (IARC) classifies acrylonitrile as a possible carcinogen, citing inadequate evidence in humans for a definite determination (IARC 1999a). Butadiene is classified as a ''probable human carcinogen'' by the IARC (1999b), and exposure can cause eye, nose, and throat irritation, damage to the central nervous system, heart, and lungs (National Pollutant Inventory 2010b), and has been associated with increased incidence of leukemia in synthetic rubber workers (Macaluso et al. 1996). The main sources of butadiene emissions are petroleum refining and synthetic material manufacturing, though the chemical is also present naturally in forest fires and the burning of other natural biomass materials. While acrylonitrile, butadiene, and nitrile itself are used to manufacture products beyond the medical supply industry, the use of these chemicals in the production of medical gloves does pose risks to human health and the environment.

While our case study to investigate the upstream impacts of medical supply chains indicates the range of consequences occurring upstream of the point-of-care, the difficulties we encountered highlight several areas for further examination. First, the amount of time and effort needed to track down information on commodity chain impacts may be prohibitive to institutions seeking to compare the environmental, occupational, and public health outcomes of various product alternatives. Second, even if such data were easily attainable, purchasing administrators and product evaluation and selection committees responsible for selecting materials and supplies would need knowledge and training in how to compare unquantifiable social and environmental life-cycle impacts of commodity chains. Finally, since the medical supply closets at each of our research sites were filled with items made or assembled outside of the U.S., it is difficult to make solid conclusions about the upstream impacts of these supply chains. This finding, in particular, argues for a need for greater transparency in product labeling.

Generation, Handling, and Disposal of Medical Waste

We identified the improper disposal of waste as a routine practice that led to environmental, occupational, and public health impacts of routine waste disposal practices at our research sites.

Downstream of the point-of-care, waste disposal practices have potential adverse health consequences that may affect individuals ranging from housekeepers just downstream from the moment of waste generation, to entire communities living near landfills and incinerators. Culturally, the saying, ''reduce, reuse, recycle'' implores Americans to minimize waste, but none of the units we studied employed such practices routinely. Within the past decade a wide scale shift away from reusable materials that could be cleaned, sterilized, and reused and toward disposable single-use items has greatly increased the amount of medical waste (Diconsiglio 2008). One reprocessing staff member stated, ''I came from an era where a lot of devices were reused, we cleaned them and reused them. Then people started questioning the ability to clean these things well enough… [and] that's when we really started throwing things out.'' A combination of federal infection control policies requiring some medical interventions to become

single-use, and the costs of maintaining a facility and workforce to reprocess supplies led our hospital site to switch to disposable options for the majority of their supplies, and the hospice facility was built after the national switch to single-use items. However, we were surprised to learn that a large number of single-use medical supplies are in fact recyclable (e.g., IV bags, tubing). The successful recycling of medical supplies could reduce both the volume and impacts of medical waste, but a lack of clear recycling guidelines and best practices at our research sites led to the disposal of these resources.

A surgical nurse at the hospital described a recycling program that had recently been implemented in the operating room, and stated that surgeons contaminated the recycling bin by throwing their gloves inside. When asked why she thought that was happening, she said, ''They just have other things on their minds. I don't think they do it to be malicious, and I don't think they're doing it on purpose. They scrub out and they want to get out of there.'' When nursing staff developed a recycling program on our hospital inpatient units, they reported witnessing similar contamination incidents when physicians disregarded posted signs and tossed waste into recycling bins. Such actions expose recycling workers to potentially infectious waste and, according to a housekeeping administrator, in this case halted the hospital's inpatient recycling program to avoid possible fines levied by the state. We contacted the recycling hauler/processor to investigate what had happened and learned that workers at the recycling facility began seeing medical waste on the conveyor belts where they were sorting materials from the hospital. As a result, the hospital was forced to scale back its recycling program—effectively sending recyclable materials from patient care areas to the landfill.

Contamination issues also posed problems to workers handling other waste streams. Housekeeping and environmental services staff members responsible for collecting and disposing of municipal waste frequently came into contact with improperly disposed infectious waste. Hospital supervisors who trained new waste handler employees would randomly select ''regular trash'' bags from the dumpster awaiting pickup, and open them to see what was actually inside. These checks showed new employees that even seemingly typical municipal trash bags may in fact be carrying hazardous waste, and that they should therefore exercise appropriate caution at all times. During the course of our observations, we observed a supervisor inspect four bags of trash destined for the municipal waste stream, bound for the local landfill. The first three bags contained materials that were appropriate for landfilling (though some could have appropriately been recycled): plastic and paper procedure drapes, gloves, a heart catheter, empty syringes, suction tubing, IV bags. The fourth bag, however, contained suction tubing and a clear plastic suction container with a bright green lid that was full of bloody phlegm and fluid. The supervisor seemed unsurprised and said that infectious waste was improperly disposed of all the time.

Following the infectious waste further downstream, we observed additional hazards to employees at the facility that processed infectious waste. When a load of ''red bag'' waste arrived at the plant, it was steamed to about 280°F, hydraulically lifted and dumped into a large grinder, and then sent up a conveyor belt where it passed beneath six different microwave units and was finally dumped into a trash compactor. After going through this process, the waste was deemed safe enough for the local landfill—at a total rate of about 2 million pounds (1,000 tons) each year for all the medical facilities the processing plant served. An administrator explained that the workers here often discover inappropriate articles in the infectious waste stream. Of particular concern were large metal items such as staplers or other mechanisms. The administrator explained, ''Primarily coming out of surgery…they'll throw a stainless steel hip joint in with the red bags. Well, those sorts of things will plug up our machines.'' When the grinder gets locked up, ''one of our guys, our maintenance guy or one of our operators has to go down inside of that hopper to…unplug it…By doing that, you've exposed that person to all of those contaminants and hazards that are inside that hopper.'' Although the waste had been steamed before it reaches the hopper, this administrator worried that it may still have contained sharps that had not yet been ground up. He explained that this is such a high source of concern for his employees that they will sometimes open bags to inspect them before adding them to the grinder. This, however, almost certainly exposes workers to risk of injury. ''So if our guys suspect that there's something in one of the red bags that shouldn't be in there, then they will open up the red bag [before it is processed] with the rationale that it's better to open it up outside of the machine and expose yourself to something that you have better control over and you can…get more [personal protective equipment] on than getting yourself exposed to all of that stuff down in that hopper. So we say it's the lesser of two evils and we choose to open that one bag up outside instead of waiting

for it to get in there and plug up, and have to pull out thirty bags of stuff that's on top of that one thing.''

The improper disposal of infectious waste disproportionately harms the working poor and persons of color since housekeeping and other downstream labor positions are blue-collar jobs that tend to be held by these groups. At the hospital, 53% of the waste handling work force was from non-white populations, 35% of whom spoke English as a second language. At the hospice facility, 20% of the downstream workers were Latino/a, and 50% of all waste handling staff spoke English as a second language.

Items may have ended up in the wrong waste stream for a variety of reasons, but the accounts we have heard of improper disposal reveal that downstream health concerns hold less weight than other factors in the patient care arena, and makes visible the way various actors have different levels of power (e.g., nurses who implement recycling programs versus physicians who disregard recycling practices, employees who handle waste versus healthcare professionals who care for patients) which may explain why some occupational groups have greater risk of health exposure.

Pharmaceutical Handling and Disposal

Our research revealed three routine institutional practices related to environmental, occupational, and public health impacts of pharmaceuticals: (1) occupational exposures to hazardous chemotherapy agents, (2) hazardous waste incineration that disproportionately impacts the working poor and minority communities, and (3) down-the-drain pharmaceutical disposal which poses potential risks to ecosystems and human health.

Occupational exposures to chemotherapeutic agents pose several health risks to hospital staff. Chemotherapy agents are a mainstay of cancer treatments but produce many side effects including infection, anemia, nausea, vomiting, hair loss, mouth sores, diarrhea, and infertility (American Cancer Society 2009). For patients, the benefits of chemotherapy in extending life outweigh these side effects, but the adverse health outcomes of exposures to many chemotherapy drugs classify them as hazardous substances (Connor and McDiarmid 2006). Nurses are exposed to chemotherapeutic agents when administering them to patients, and housekeepers may be exposed to excreted agents when handling soiled linens and other materials. As a result, staff members exposed to chemotherapy agents have an increased incidence of reproductive problems including miscarriage and stillbirth (Valanis et al. 1999; Environmental Working Group 2007), infertility, premature delivery, and low birth weight infants (Fransman et al. 2007). An unfortunate irony is that staff members who are exposed to anti-cancer agents may also have an increased risk of developing leukemia (Skov et al. 1992).

Nurses who administered chemotherapy treatments are trained to wear protective gowns and gloves to minimize their exposure, but not all nurses felt that they were adequately protected. A nurse on the conventional cancer unit said that healthcare workers would still be exposed if a substance sprayed or spilled when IV bags and tubing were changed. Moreover, while nurses were trained to wear special gowns and gloves when administering chemotherapy, some nurses chose not to wear masks that were recommended for their protection. As one nurse said, ''…the way the drug is administered can affect the way the patient feels about what you're putting into their body…If you walk into the room with goggles and gown and mask, and they're like okay this is what you're putting in me and you can't even come into contact with it?'' This nurse went on to say, ''some nurses on the floor, if they're trying to get pregnant or are pregnant, they have the personal option to choose not to handle the drug. And that's totally acceptable on our floor, but you couldn't work on our floor [long-term] and not give chemo. I mean, all our nurses are chemo certified and it's expected that you give it.'' Nursing staff therefore experienced a tension between enhancing a patient's comfort, managing their professional careers, and their personal safety.

Looking further downstream, we identified a range of environmental and human health concerns related to pharmaceutical waste disposal. On the conventional and palliative care units, pharmaceutical waste was placed in large, lockable black plastic bins kept in the unit pharmacy room. From there the bins were taken to a locked storage area in the basement until they were mingled with other forms of hazardous waste generated in the hospital, picked up by a licensed hazardous waste hauler, and eventually transported to a hazardous waste incinerator. Such hazardous waste facilities are disproportionately sited in minority communities (Bryant and Mohai 1992; Brown 1995). The incinerator that processed the waste from our research sites was located in Port Arthur, Texas—a community that is about 80% African American and Latino (Cole 1994). Toxic ash that resulted from the incineration process was then transported to a hazardous waste dump in Emelle, Alabama. This toxic waste landfill is the largest of

its kind in the U.S., and was sited in a poor rural community in 1978 when there were no minority representatives on the county industrial development board, county commission, or in the state legislature (Bullard 2000). Though hazardous waste incinerators are highly regulated by the Resource Recovery and Reclamation Act and are equipped with a number of scrubbers to minimize emissions (EPA 2011), these facilities are associated with a number of public health concerns due to the release of heavy metals such as mercury, cadmium, and chromium; dioxins and furans; and organics such as PCBs, benzene, and toluene during incineration (Sedman and Esparaza 1991; Rowat 1999; HCWH 2002). The environmental justice issues faced by the poor and minority communities living near hazardous waste facilities are made worse by the fact that the minority populations most burdened by pollution are underserved by the healthcare community (Shavers et al. 2012).

Of concern to this study was the fact that not one of our participants—not even administrators at the hospital—knew the ultimate fate of the pharmaceutical waste. They simply knew it was picked up by a contracted company and hauled away for incineration. Since drug waste has a number of potential environmental and human health impacts (Daughton 2001, 2002, 2003), the lack of knowledge about the processes and ultimate locations of pharmaceutical waste again illuminates how downstream consequences of healthcare operations hold less weight than other patient care factors.

On the hospice unit, the majority of pharmaceutical waste was also disposed of via incineration, and was collected by the same hazardous waste hauler contracted by the hospital where our other two sites were located. However, nurses on the hospice unit commonly flushed unused portions of narcotics down-the-drain. When we inquired about this practice, we learned two important facts. First, flushing narcotics down-the-drain had evolved as the way hospice staff could most easily comply with Drug Enforcement Agency (DEA) regulations put in place to prevent drug diversion (see Office of National Drug Control Policy 2009). Little is known about the human health effects of exposure to drugs that end up in the water system, but there are some concerns regarding long-term exposure to the cocktail of pharmaceutical residues in drinking water because treatment plants are unable to filter them out (Daughton 2003). Certain impacts of drug waste in the aquatic environment have received greater attention, including reproductive problems in fish exposed to medications, particularly birth control pills (Corcoran et al. 2010). When asked about the environmental impacts of flushing drugs down-the-drain, a hospice pharmacist said, "The DEA scares us more than the EPA. They have guns and can put you in jail. The EPA might fine you."

Second, flushing drug waste down-the-drain was the preferred method of pharmaceutical disposal for hospice nurses working with patients who remained in their own homes. "Pretty much everything just goes down-the-drain," according to one hospice nurse. This is particularly important since about 40% of hospice patients received in-home care (the remaining 60% of patients received hospice care in nursing homes or other medical facilities). Only 6% of all patients were ever admitted for short-term acute care to the hospice inpatient unit where unused drugs were disposed of via regulated incineration. As a result, we presume that a large volume of unused pharmaceutical products were disposed of down-the-drain by hospice nursing staff within patients' homes, but no one can quantify the amount of drugs that were flushed. Our qualitative approach has identified that the cumulative impacts of down-the-drain pharmaceutical disposal from in-home hospice care where all drug waste was flushed into the wastewater stream warrant consideration, but further research is needed to quantify this problem.

Dumping drugs down-the-drain was standard practice for in-home patients for a number of reasons. First, in-home nursing staff members were unable to transport drug waste back to the hospice facility for disposal because they did not have room in their vehicles. Second, such transport would have required, at minimum, using locked boxes to comply with DEA guidelines for managing controlled substances. And third, down-the-drain practices emerged as a way for the hospice institution to navigate directives for handling hazardous waste from multiple agencies (in this case the DEA and EPA) because hospice accrediting agencies do not provide clear guidelines on the topic. In setting protocols, the rules from the more powerful agency, or the rules that have more direct financial or criminal consequences for individuals and the institution took precedence.

Level of Staff Environmental Concern

Staff interest and concern over these environmental problems varied. During observations, the vast majority of the staff members at the teaching hospital brought up the need for better recycling within the facilities but only one

participant, a nurse who had spent time volunteering in a developing country, discussed further connections between resource use, clinical practices, and environmental challenges. Staff members at the hospice facility were similarly quiet on the subject of environmental connections to their work, though more discussed programs in the facility such as donating unused supplies to underserved populations.

Regarding our case study to investigate the life-cycle impacts of nitrile gloves, we asked several staff members whether information about adverse health and environmental effects in the manufacturing process of medical exam gloves would change the way these supplies are chosen and used in patient care. A purchasing administrator replied, ''I think that would be driven by the users because if the items came with warnings or if they heard through the media that the use of this product is causing [illness], or some poor kid in a sweatshop in India is making this, yeah I think it would [be considered].'' After a moment he added, ''Then again you'd have to see, is there something else? Let's say the alternative is better in that respect but it won't do the same job for the patient. So are you willing to say that you would go and do something less for the patient because of this concern about something else?'' This comment raises the question of how to weigh the life-cycle impacts of commodity chains against concerns for patient safety and satisfaction.

Interviews with administrators at each site revealed that environmental concerns had driven some decisions in the past. For example, nursing and housekeeping staff at the hospital had voiced concerns about the amount of waste being generated when the product evaluation and selection committee switched from reusable to disposable basin sets in the operating room to reduce costs. One purchasing administrator stated, ''So the compromise we came up with is that we take the disposable basin sets that are designed to be thrown in the landfill, and we…run them through the washer/decontaminators and then recycle them. So that was a way to compromise with our green staff and made them feel better about what we're doing. So we try to be green but there are times when we just can't so we try to find ways to mitigate the negative influence.''

The statement, ''sometimes we just can't,'' again shows how even in cases where ''green'' concerns are raised other factors take precedence within the patient care arena. It also exemplifies how certain actors hold power over others. The relative influence of various actors shapes resource use decisions, which in turn shape upstream and downstream consequences of healthcare operations.

Conclusions

Current institutional practices in healthcare settings involve unsustainable and often wasteful use of material resources that have potential impacts on the natural environment and human health. Our qualitative approach of observing patient care and following commonly used medical supplies and pharmaceuticals upstream and downstream from the bedside has identified the types and range of impacts that result from healthcare operations, and suggests areas that warrant further investigation. Three major areas of concern arose from our analysis: medical supply procurement; generation, handling, and disposal of medical waste; and pharmaceutical handling and disposal. Overall, our characterization of impacts illustrates how the environmental, occupational, and public health impacts that result from healthcare operations are routinely externalized without consideration of the true cost (social and environmental) of patient care. This externalization occurs in various ways within the routine operations that we observed. Regarding medical supply procurement, we found that clinical and economic matters overshadowed possible concerns for the broader impacts of commodity chains. Our observations of medical waste streams illuminated the importance of power dynamics between healthcare workers in the externalization of environmental and human health concerns, both in terms of physicians who contaminated recycling programs piloted by nurses, and clinical staff who exposed waste handlers to infectious waste through improper disposal practices. Power dynamics also contributed to the consequences of pharmaceutical handling and disposal: concerns over patient satisfaction with care overshadowed the risks of occupational exposure to chemotherapeutic agents and led nurses to opt out of wearing recommended protective equipment when administering these drugs; occupational and public health exposures to hazardous waste reflected the power of clinical care over waste handling staff and environmental justice communities; and the power of the DEA over environmental concerns led to down-the-drain drug disposal practices. In general, these findings reflect the relative influence of certain actors in shaping and externalizing the broader social and environmental impacts of healthcare.

These findings also highlight possible points of intervention for internalizing the environmental, occupational, and public health consequences of medical care.

Nonprofit advocate organizations such as Health Care Without Harm and Practice Greenhealth have done much to increase the awareness of the ecological impacts of healthcare, but there are a number of potential governance strategies that could bolster the "greening" of healthcare. Incentivizing and implementing standardized EPP programs could streamline the process of product evaluation and enhance the ability of medical facilities to select products that meet the purchasing decision criteria of being clinically acceptable and economically feasible, while also being safe for the environment and human health. Stiffer penalties for the improper disposal of waste could mitigate the occupational and public health exposures faced by workers and communities living downstream of the point-of-care, as could strategies such as cradle-to-cradle product design and restructured infection control policies that would decrease medical waste generation. Increased awareness and incentives/penalties could encourage nurse compliance with personal protective equipment recommendations for minimizing exposure to hazardous drugs; and collaboration between the DEA and EPA could lead to more effective drug diversion and disposal strategies that take environmental and human health concerns into account.

In general, the current lack of regulations surrounding healthcare sustainability initiatives restricts the number of institutions actively working to mitigate the environmental consequences of their practices. A combination of other governance mechanisms for increasing participation in greening programs warrant exploration, such as regulations from accrediting agencies, government regulations, and directives that encourage voluntary green supply chain management (Arimura et al. 2011). Adding mechanisms to incentivize medical facilities to examine and address the environmental and human health impacts that result from their practices could help move medical care toward an approach that takes a more holistic view of health while also providing high quality patient care.

Together, these strategies imply the need for greater awareness, education, and regulation to minimize the environmental, occupational, and public health impacts of healthcare. However, as evidenced by several of our observations and interviews, the broader consequences of healthcare will remain on the sideline until a balance is found between the power of health and safety concerns at the patient level, with those at the community level.

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