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Innovative Application of Bar Coding Technology to Breast Milk Administration

Ellen K. Fleischman, RD, RN, MBA, MSN, NE-BC

ABSTRACT

Hospitalized infants often receive expressed breast milk, either from their mother or from banked milk. Breast milk provides optimal nutrition for infants but because it is a body fluid it carries the risk of disease transmission. Therefore, administering the correct breast milk to hospitalized infants is essential. Bar coding technology, used in hospitals to prevent errors related to medication administration, can be proactively applied to prevent breast milk administration errors. Bar coding systems offer advantages over manual verification processes, including decreasing errors due to human factors and providing for automated entry of feedings in the electronic health record. However, potential barriers to successful implementation must be addressed. These barriers include equipment and training costs, increased time to perform the additional steps with bar coding, and work-arounds.

Key Words: administration errors, bar coding, breast milk

In the Institute of Medicine's landmark report, To Err is Human, it was reported that as many as 98 000 people die every year as a result of medical errors. One of the strategies outlined in the report to decrease medication errors and improve patient safety is to implement safety systems to ensure safe practices at the delivery level.[1] Two methods used by hospitals to improve patient safety are computerized physician order entry through electronic health records and bar code medication administration (BCMA) systems. While the focus of computerized physician order entry is on preventing order errors, additional errors can occur in the dispensing, transcribing, and administering phases.[2] In October, 2012, the Centers for Medicare & Medicaid Services issued Measure 16 of the Phase 2 Meaningful Use Core Measures, requiring hospitals to begin tracking medications from order to administration using "assistive technologies in conjunction with an electronic medication administration record."[3] The effectiveness of utilizing bar coding technology to provide the correct medication to the correct patient has been well documented. Poon et al[4] conducted a quasi-experimental study before and after successfully implementing bar coding of medications and found a 41.4% relative reduction in errors after bar coding ($P < .0001$). Wright and Katz[5] found that implementing medication bar coding at 1 hospital reduced medication errors by 50% and prevented approximately 20 adverse drug events per day. Bar coding systems offer the advantages of increased accuracy and decreased human error due to manual processes, automated data collection, and real-time feedback. Point of care bar coding can help hospitals comply with the Joint Commission's National Patient Safety Goal 1 to improve the accuracy of patient identification. The intent of the goal is to verify that the correct patient is being treated and that the treatment the patient will receive is appropriate.[6]

While hospitals will be required to utilize bar coding for medication administration, an innovative application of bar coding is to proactively apply this technology to improve the safety of breast milk administration. The incidence of breast milk administration errors is not widely reported. One hospital reported an error rate of 1.04 errors per month for every 10 000 monthly feedings.[7] A second hospital reported 80 errors over a 10-year period, only 1% of which could be attributed to name similarities.[8] At Sharp HealthCare in San Diego,

Author Affiliation: Maternal Infant Services, Sharp Mary Birch Hospital for Women & Newborns, San Diego, California.

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Corresponding Author: Ellen K. Fleischman, RD, RN, MBA, MSN, NE-BC, Maternal Infant Services, Sharp Mary Birch Hospital for Women & Newborns, 3003 Health Center Dr San Diego, CA 92123 (ellen.fleischman@sharp.com).

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California, the incidence of breast milk administration errors at its 3 hospitals with neonatal services was very low. However, due to the risks associated with providing the incorrect breast milk to fragile infants, the organization elected to implement breast milk bar coding prior to the implementation of medication bar coding.

When hospitalized infants are separated from their mothers and are not able to feed directly at the breast, the infants often receive feedings of expressed breast milk. Expressed breast milk is transferred into storage containers and may be refrigerated or frozen, rather than consumed immediately. Process steps between collection and administration create many opportunities for error. Breast milk is a body fluid that carries the risk of transmitting infectious disease such as human immunodeficiency virus (HIV) and hepatitis; therefore, precautions must be taken to ensure that infants receive the correct breast milk.[7] The purpose of this article was to present the application of bar coding technology to breast milk to decrease administration errors. The significance of breast milk to the health of newborn infants will be reviewed, as well as the advantages and disadvantages of breast milk bar coding. Potential barriers to implementing breast milk bar coding will be reviewed.

SIGNIFICANCE OF BREAST MILK FOR NEWBORN INFANTS

Extensive evidence exists to support the importance of breast milk as the optimal source of nutrition for infants. Exclusive breast-feeding for at least the first 6 months of age is recommended by most medical and professional organizations including the American Academy of Pediatrics and the World Health Organization. Breast milk, either fed directly or expressed, is the recommended feeding for infants.[9] The significance of breast-feeding to the health of infants, as well as the impact of health into adulthood, is demonstrated by the inclusion of 8 breast-feeding goals in the *Healthy People 2020* report. These goals include increasing the percentage of infants who were ever breast-fed from 74% to 81.9% and increasing the percentage of infants who were exclusively breast-fed through 6 months from 14.1% to 25.5%.[10] Breast milk contains antibodies to common bacteria and is especially advantageous to infants because of the many immune-enhancing benefits it offers, such as a reduction in the incidence of necrotizing enterocolitis (NEC), decreased respiratory tract infections, and sepsis.[11] Although the cause of NEC is not known, formula-fed infants are at higher risk for NEC, and infants fed breast milk receive a protective effect.[12] Bartick and Reinhold[13] reported that with 90% compliance with exclusive breast milk feeding, NEC deaths would decrease by 249 per year. Breast-feeding is also associated with a reduced risk of sudden infant death syndrome. There are additional benefits of breast-feeding that are evident in adulthood, including a lower risk of obesity and type II diabetes later in life.[11] If 90% of families in the United States exclusively breast-fed their infants for 6 months, it is estimated that the United States could save $13 billion per year and prevent an estimated 911 deaths.[13] In 2009, the American Academy of Pediatrics endorsed the World Health Organization/United Nations Children's Fund Ten Steps to Successful Breast-Feeding. These steps are evidence-based practices that hospitals should follow to promote breast-feeding. Hospitals that implement the Ten Steps and meet the established criteria can seek designation as a Baby Friendly Hospital.[14] As hospitals move to provide evidence-based care to support breast-feeding and increase breast-feeding rates, the number of opportunities for breast milk administration errors may rise.

IMPACT OF BREAST MILK ADMINISTRATION ERRORS

Administration of the incorrect breast milk can result in the transmission of infectious diseases, including cytomegalovirus (CMV), HIV, and hepatitis B. Because hepatitis C is transmitted through blood, the risk of transmission through breast milk is very low. According to the Centers for Disease Control and Prevention, breast-feeding by hepatitis C–positive mothers is only contraindicated if the mother's nipples are cracked and bleeding.[15] Dougherty and Nash[8] reported 80 breast milk administration errors in an 11-year period, and although there were no known transmissions of HIV, hepatitis, or CMV, 4 infants were treated prophylactically when the donor mother tested positive for hepatitis B. While healthy term infants are at lower risk of contracting CMV than preterm infants, breast milk is the main source of CMV infections in infants.[8] A prospective study of 30 mothers and 43 preterm infants by Yasuda et al[16] found that 24 of 30 (80%) of mothers with preterm infants were CMV immunoglobulin G–positive. CMV DNA was detectable in the breast milk for 21 of the 24 (87.5%) mothers, and 3 of the infants fed CMV DNA-positive milk developed CMV infection.[16] In the United States, breast-feeding is contraindicated for mothers who are HIV positive. Although infants rarely contract HIV through breast milk, the potential for HIV infection via administration of the incorrect breast milk exists because not all mothers are screened to determine their HIV status prior to delivery. Breast-feeding is not contraindicated for mothers who test positive for hepatitis B; therefore, an infant who receives the incorrect breast milk could potentially contract hepatitis B infection. When a breast milk error occurs, hospital

policy likely includes obtaining consent for HIV testing of the donor and authorization to disclose results to the recipient infant's parents. In addition, a root cause analysis should be conducted to evaluate systems and processes that led to the error. Breast milk administration errors can result in increased costs from additional tests and erode the trust and confidence of patients and their families.

MANUAL BREAST MILK VERIFICATION PROCESSES

Hospitals provide expressed breast milk to infants in several ways, including bolus feedings via orogastric or nasogastric feeding tube, bottle, syringe, or cup.[8] The process for transporting expressed breast milk from the mother to storage and eventually to the infant has multiple steps. The milk must be labeled for the correct infant, and it must be dated and timed so that the expiration can be determined. Before the breast milk is administered, the label on the storage container must be checked against the infant's identification band. This process is repeated multiple times for each infant and often for more than 1 patient per nurse. In a 60-bed tertiary care neonatal intensive care unit (NICU) it was estimated that 12 840 breast milk and formula feedings were administered monthly, creating numerous opportunities for error.[7]

Dougherty and Nash[8] described the manual process for breast milk verification at Sunnybrook Health Sciences Centre in Toronto, Canada, prior to the implementation of breast milk bar coding. Breast milk was stored in a refrigerator bin assigned to a particular infant. The milk was then removed, and a double check was performed, comparing the container's label against the infant's crib card. The authors reported 80 breast milk identification errors between 1996 and 2007. They concluded that manual systems are prone to more error, such as forgetting to check the breast milk label against the infant's identification band or assuming that breast milk taken out of a storage bin for a particular infant precludes checking the breast milk label against the infant's identification band.[8]

One source of errors with manual verification systems is related to inattentional blindness. Inattentional blindness is a term used to describe a phenomenon when a person fails to see an object or detail because his or her attention is not focused on it.[17] For example, this could occur when a nurse takes breast milk out of a bin corresponding to an infant's bed number and does not see that he or she has the wrong milk when looking at the breast milk label. Dougherty and Nash[8] reported that at their facility it is likely that many additional errors escaped identification. In the process of analyzing the errors, no patterns were apparent: they occurred on all shifts, and experienced nurses were as likely as newer nurses to make identification errors. It was concluded that the visual double check was unreliable, and the common denominator in each error was the human factor.[8]

AUTOMATING BREAST MILK VERIFICATION

Just as with bar coding of medications, bar coding of breast milk offers an informatics solution to decrease administration errors due to human factors and offers several advantages over manual verification processes. One goal of bar coding medication systems is to confirm the 5 "rights" of medication administration, including the right patient, right drug, right dose, right route, and right time, rather than relying on human factors.[5] With breast milk bar coding, the 5 "rights" would be the right patient, right feeding, right volume, right route, and right time. Breast milk is unique, in that the nutritional composition of milk is designed to meet the unique needs of the infant. For example, breast milk composition changes during a feeding; milk at the beginning of a feeding is lower in calories and fat than milk at the end of the feeding.[18] As with medications, attention must be paid to the expiration date for breast milk. Although facility policies vary, according to the Centers for Disease Control and Prevention, breast milk for healthy term infants can be kept in the refrigerator for 5 days and in the freezer for 2 weeks.[15] By automating the breast milk verification process, in addition to providing verification that the caregiver has the correct feeding to the correct patient, the system may include verification that the feeding has not expired. When combined with an electronic health record, documentation of the feeding can be automated through the scanning process. The bar coding system can also be used to generate reports to analyze the administration of breast milk, including the number of feedings provided, the number of critical alerts, and the type of critical alerts by caregiver. This information can be used to determine areas in which potential errors could occur and how to prevent them.

Sharp HealthCare

One organization that recently implemented breast milk bar coding is Sharp HealthCare, a regional integrated health system in San Diego, California, with 4 acute care hospitals, 3 specialty hospitals, skilled nursing facilities, and ambulatory care facilities.[19] At Sharp HealthCare, breast milk bar coding has been implemented in all of the hospital NICUs, and plans are in place to implement the same system in well baby units. The organization implemented an electronic medical record

including physician order entry at all its hospitals starting in 2009. Planning for the implementation of a hospital-wide bar coding initiative, including breast milk administration, blood transfusion, point of care laboratory specimen collection, and medication administration, began in 2011 as part of the organization's safety plan. Representatives from each hospital participated on a Breast Milk Bar Coding Task Force, which included Information Systems, Clinical Nurse Specialists, Lactation Services, Supervisory staff, and nurse executives. Breast milk bar coding replaced the manual verification process, which includes verifying that the person providing the breast milk has an identification band that matches the infant's identification band, checking for correct labeling of the breast milk, verified by 2 nurses prior to feeding.

BREAST MILK BAR CODING OPERATIONS

Hospitals interested in implementing breast milk bar coding may elect to expand the use of an existing bar coding system or purchase a stand-alone system. In 2005, an interdisciplinary group at Sunnybrook Health Sciences Centre in Toronto, Canada, collaborated with a company called LacTrac Safe Lx to develop a bar coding system for breast milk.[8] This program bridges the current electronic health record with a bar coding system, and as a result, scanned information can be imported into the electronic health record. The system includes hardware such as portable and attached scanners, as well as label printers for breast milk identification. The technology used was similar to the system used for blood transfusions. With this system, when an infant is admitted, a bar code is generated with last name, gender, date of birth, and medical record number. At this facility, the infant's bar code is attached to the crib card, which is kept in the infant's incubator or crib. The staff members utilize a personal digital assistant to scan their personal bar code, scan the infant's identification bar code on the crib card, and then follow the prompts. The system includes 3 auditory sounds: a soft "bing" sound for a successful scan, a soft "bong" sound for a minor alert, and a siren alarm for a major alert. A minor alert prevents the user from moving forward, and there is a visual prompt, such as a message indicating that the user has scanned the incorrect bar code. With a minor alert, the user can continue when the error is corrected. A major alert or critical alert can be triggered when there is a mismatch between the bar code on the infant's crib card and the bar code on the breast milk, when too much time has elapsed from the feeding being prepared, or a mismatch between the label and the infant's feeding order. The user is unable to move forward until the problem is corrected, and the scanning process must start from the beginning. Data are downloaded wirelessly so that the process can be analyzed.[8]

Sharp HealthCare elected to utilize a bar coding product from the existing electronic health record vendor. Figure 1 depicts the handheld scanner and label printer utilized by this system.

There are several phases to the workflow of breast milk bar coding systems. The receive phase includes scanning the milk into the system and pairing it with the infant's identification label. The prepare phase is the point at which breast milk fortifiers can be added. Finally, in the administer phase, the user logs into the system and scans the identification label. If there is a match and the breast milk is not expired, the user scans that the process is complete. If there is not a match, the system displays a mismatch message, along with the option to retry or cancel the process. A sample of the administer process used at Sharp Health Care is depicted in Figure 2.

BARRIERS TO IMPLEMENTING BAR CODING

Costs to implement a breast milk bar coding system include the cost to purchase software, scanners, and other hardware, as well as expenses for staff training time. Software and hardware costs vary by vendor and size of the facility. Hardware may include additional bedside computers, handheld scanners, and label printers. Training time includes not only the time for staff training but also training for superusers to learn the system and to support the regular users during the go-live phase. At Sharp Health Care, the initial training time was 4 hours per nurse, plus additional time for superusers and go-live support. Patient assignments may also need

Figure 1. Breast milk scanner and label printer.

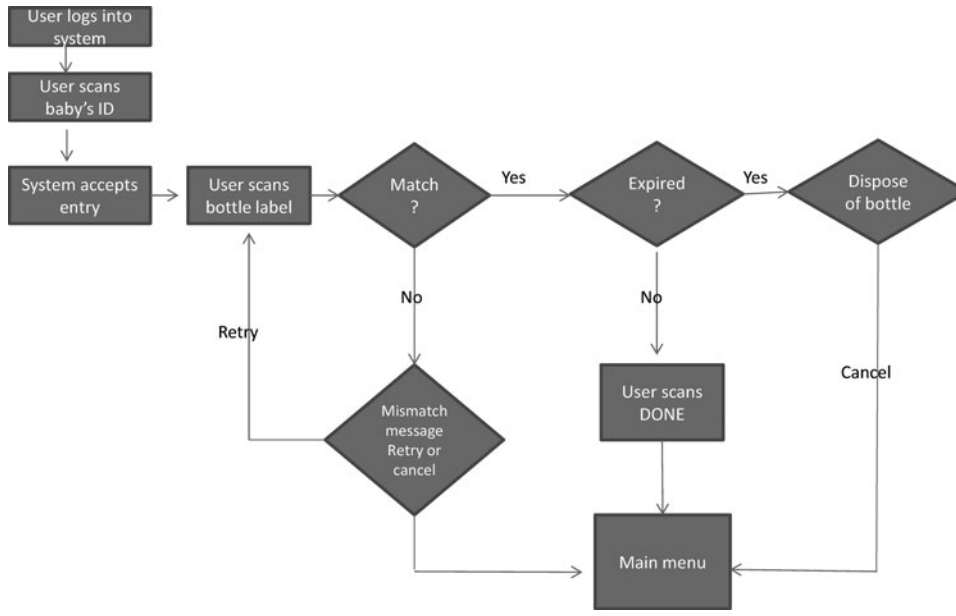

Figure 2. Breast milk administration.

to be reduced during implementation to account for the additional time to complete the new process.

While the goal of breast milk bar coding is to decrease administration errors and improve patient safety, more time is required to receive, prepare, and administer a feeding than with a manual process. At Sharp Health Care, nurses initially reported that the process can take an additional 15 to 20 minutes per feeding, a process that is repeated many times a shift. Breast milk bar coding was implemented at Sharp hospitals with smaller NICU units prior to implementing the system in the largest NICU. In addition to a higher census and higher acuity patients, the larger NICU has more breast milk fortification, which adds additional steps in the workflow. At this facility, training and implementation of the new system coincided with a period of very high census. This created challenges providing adequate training while staffing the unit. In addition, it was determined that to decrease the impact on workflow, a scanner and computer are needed at each patient's bedside (B. Malebranche, oral communication, December 2012).

Disadvantages of breast milk bar coding are similar to the disadvantages of BCMA systems. Breast milk bar coding and BCMA systems usually include a handheld device for scanning bar codes, and staff can feel "tethered" to the equipment and may have to roll computers and scanners from room to room. There may not be enough space for bedside computers and not enough storage space elsewhere on the unit.[5] Hand-held scanners are expensive and may be dropped and damaged, resulting in replacement costs.

Another disadvantage is the potential to develop workarounds to circumvent the system and bypass safety features. Koppel et al[20] studied BCMA systems at 5 hospitals. The authors observed nurses utilizing BCMA systems, interviewed staff, participated in Failure Mode and Effects Analysis analyses, and reviewed BCMA override data.[20] The authors identified 15 types of workarounds and 31 probable causes of these workarounds. Workarounds were grouped into 3 categories: omission of process steps, steps performed out of sequence, and unauthorized BCMA process steps. Most of the workarounds described could be applicable to breast milk bar coding. One of the potential workarounds described by Koppel et al[20] that would *not* be applicable to breast milk bar coding is related to medication packaging. A user can scan medication packaging multiple times instead of scanning each package. With breast milk, the breast milk container is discarded after the milk was fed to the infant, theoretically eliminating this potential workaround.

RECOMMENDATIONS

Implementing a breast milk bar coding system offers the opportunity to decrease errors due to human factors, provide for data collection related to feeding, and potentially automate feeding information in the electronic health record. Each facility will need to evaluate its resources and determine the best course of action to meet its needs. Successful implementation of breast milk bar coding will be affected by making process improvements before automation begins, overcoming

barriers such as training time and expenses, software and hardware expenses, workflow adjustments to account for the extra time to complete the feeding process, and preventing work-arounds that can undermine safety processes.

SUMMARY

Bar coding of medications has been implemented in hospitals to decrease medication administration errors and improve patient safety. While hospitals will be required to utilize this technology with medication administration, breast milk bar coding is not mandated. Breast milk is the recommended source of nutrition for infants, and hospitalized infants often require feedings of expressed breast milk. Breast milk administration errors can result in disease transmission, additional tests, and the loss of trust from patients and their families. Verification processes are necessary to ensure that the right feeding goes to the right patient; however, manual verification processes are prone to human error. Breast milk bar coding offers a technological solution to improve the safety of breast milk administration and may offer additional advantages, including generating real-time reports and automating the documentation of feedings. Barriers to successful implementation include costs of hardware, software, and training time. Disadvantages include additional time as compared with manual processes, interruptions in workflow, and the potential for error despite automation. Automated point of care processes are likely to become a way of life in hospitals, and hospitals caring for infants may elect to implement breast milk bar coding to improve patient safety.

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