Cost-Effectiveness of Postnatal Home Nursing Visits for Prevention of Hospital Care for Jaundice and Dehydration

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ABSTRACT. Objectives. (1) To describe the relationship between postnatal home nursing visitation and readmissions and emergency department (ED) visits for neonatal jaundice and dehydration in the first 10 days of life. (2) To evaluate the cost-effectiveness of providing home nursing visits after newborn discharge with specific attention to prevention of jaundice and dehydration that require hospital-based services.

Methods. A retrospective analysis of a financial database allowed for review of the discharge disposition and subsequent care for all neonates who were born at a single center from January 2000 through December 2002. Financial data reflect reimbursement values and costs of care from the payers' perspective at the single center. We performed a deterministic cost-effectiveness analysis using a decision tree that reflected the costs and probabilities of infants in each particular health state after nursery discharge.

Results. A total of 73 (2.8%) of 2641 newborns who did not receive a home visit were readmitted to the hospital in the first 10 days of life with jaundice and/or dehydration compared with 2 (0.6%) of 326 who did receive a home visit. Similarly, 92 (3.5%) of 2641 newborns who were discharged without subsequent home nursing care had an ED visit for these reasons in the first 10 days of life compared with 0 (0%) of 326 who did have such a visit. Of infants who received a home visit, 324 (99.4%) of 326 did not require subsequent hospital services in this time period compared with 2497 (94.5%) of 2641 of those who did not receive a visit. After nursery discharge, the average cost per child who received a home health visit was $109.80 compared with $118.70 for each newborn who did not receive a visit. The incremental cost-effectiveness ratio of a routine home visit strategy compared with a no visit strategy was $181.82.

Conclusions. A home nursing visit after newborn nursery discharge is highly cost-effective for reducing the need for subsequent hospital-based services. Pediatrics 2004;114:1015–1022; home visit, nurse, jaundice, dehydration, newborn, cost-effectiveness.

ABBREVIATIONS. LOS, length of stay; AAP, American Academy of Pediatrics; ED, emergency department; ICER, incremental cost-effectiveness ratio.

With ~4 million births per year, childbirth is the most common cause of hospitalization in the United States. Because hospital stays for newborns and their mothers are costly, attempts have been made over the past several decades to reduce postpartum length of stay (LOS). New mothers and fathers, however, have often been dissatisfied with these shorter hospitalizations. As a result of the public concern over “drive through deliveries,” the US Congress passed the Newborns’ and Mothers’ Health Protection Act of 1996, which mandated that insurance providers pay for a 48-hour hospital stay after vaginal deliveries and a 96-hour stay after cesarean section.

The Newborns’ and Mothers’ Health Protection Act of 1996 parallels the newborn healthcare recommendations of the American Academy of Pediatrics (AAP). These guidelines published in 1995 and reinforced in 2004 established minimum criteria for safe newborn hospital discharge. The AAP expert committee wrote that “it is unlikely that fulfillment of these criteria and conditions can be accomplished in <48 hours.” Furthermore, in recognition of the physical changes that occur for the newborn and the social changes that affect the family after discharge, they concluded that all newborns who are released from the hospital <48 hours after delivery must be reassessed by a health care provider within the subsequent 48 hours after discharge. Similar criteria were adopted in 1996 by the Canadian Pediatric Society. In addition, the Secretary of Health and Human Services’ Advisory Committee on Infant Mortality reported to the US Congress that all newborns should receive clinical evaluation and health promotion services on the third or fourth postnatal day.

Nevertheless, approximately half of all well newborns continue to be discharged from the hospital <48 hours after delivery. These newborns also still have a highly variable time to pediatrician-initiated reassessment, and several reports demonstrate that only one quarter to one half of all infants have clinician-initiated follow-up consistent with the AAP recommendations. Results seem particularly troublesome for the Medicaid population. More recently, infants who were insured by a Massachusetts health maintenance organization were examined on day of life 3 or 4 only 53% of the time, an 11% decrease from the previous period when insurance coverage of a 48-hour stay was not ensured by state
Because practitioner compliance with the AAP guidelines has been inconsistent and is at times impractical as a result of office hour limitations, alternative models of follow-up care must be explored.

Two of the most common problems that are identified during the early follow-up period are jaundice and dehydration. Because postnatal home nurse visitation may occur in a more timely manner than an office visit and in a period when these conditions are still developing, we hypothesized that home nurse visitation is a cost-effective intervention on the sole basis of the reduction of the use of hospital-based services for jaundice and dehydration in the first week after hospital discharge.

METHODS

Design

We performed a cost-effectiveness analysis from the payers' perspective. We chose the payers' perspective because the additional costs associated with a home nursing visit would logically be absorbed by insurers as a way to offset subsequent use of hospital-based services. A decision tree was used to model the expected costs and benefits of a home visit (Fig 1). In this model, we assumed that no infants had clinically significant jaundice or dehydration requiring intervention at the time of discharge from the nursery. At the first (square) node, the decision of whether to provide a home nursing visit is made. Once a home nursing visit is made, either the patient remains healthy with some probability or a diagnosis of jaundice and/or dehydration requiring medical intervention is subsequently made. If the patient receives a diagnosis of jaundice or dehydration, then the infant will receive inpatient therapy, emergency department (ED) care, both ED and

![Decision Tree](image)

Fig 1. Decision tree for common health outcomes in the first 10 days of life: IP, inpatient; OP, outpatient therapy.
represents how much extra payers must spend on providing home visits to prevent 1 additional child from using hospital-based services for jaundice and dehydration. The ICER is computed as follows:

$$ ICER = \frac{C_{HNV} - C_{NV}}{E_{HNV} - E_{NV}} $$

(1)

where $C_{HNV}$ is the expected cost of the home nursing visit strategy, $C_{NV}$ is the expected cost of the no visit strategy, $E_{HNV}$ is the expected effectiveness (measured in terms of hospital-based services avoided) of the home nursing visit strategy, and $E_{NV}$ is the expected effectiveness of the no visit strategy. Data from our institution was used in this cost-effectiveness model. Our decision model is deterministic because the probabilities are assumed to be fixed. Alternatively, a probabilistic model would have assumed that the probabilities were stochastic and would have averaged their distribution.

**Patients, Hospital, and Home Nurse Visit**

All newborn infants who were discharged from the newborn nursery at the Hershey Medical Center (Hershey, PA) in 2000, 2001, and 2002 were included in the cohort of patients. The Hershey Medical Center is the teaching hospital for the Pennsylvania State University College of Medicine. It is a tertiary care facility in a nonurban environment that admits ~21,000 patients per year. Eleven percent receive Medicaid, but 28% of newborns receive Medicaid. The infants in this study were term or near-term infants without risk factors, pathology, or anomalies that required more intensive care, observation, or extended nursery stay. The Institutional Review Board approved this study.

Home nurse visits were provided at the discretion of the nursery physician by private home health agencies that were not affiliated with the medical center. The visits typically consist of assessment of infant weight, jaundice, and feeding. In addition, evaluation of maternal health, parenting skills, and home environment occurs. It is the hospital practice to ensure that if home health care is prescribed, the visit occurs within 48 hours of discharge, typically by the fourth day after delivery.

**Probabilities**

Data collected from January 2000 through December 2002 were used to determine readmissions and ED visits for infants who were born at the Hershey Medical Center and returned to the same institution. Patients with visits billed with the diagnosis-related groups that correspond to neonatal hyperbilirubinemia and dehydration or feeding difficulties were then identified. Data were not available on infants who presented to other centers. LOS information correlated to calendar dates paid by the insurers as opposed to 24-hour periods of time. Hospital data were used to determine infants who were discharged to home health care. Because the numbers of patients in the home visit arm who required outpatient treatments or interventions could not be determined precisely, we estimated that an equal number of patients in the visit and no visit arms required some intervention for jaundice and dehydration. Because the home visit arm had the lower number of infant and ED visits, outpatient phototherapy was presumed to have occurred at an increased rate. Therefore, each arm had the same percentage of infants receiving an intervention for their condition only with differing percentages in the inpatient, ED, and outpatient arms. The average duration of outpatient phototherapy was assumed to be equal to the average inpatient LOS.

**Costs**

The costs of readmission, ED visitation, home nurse visitation, outpatient phototherapy, and outpatient bilirubin measurements were determined by averaging the reimbursement paid by the 9 organizations that insure 86% of patients who are cared for at this institution (Table 1). A patient who was admitted to the hospital from the ED was assessed charges from both places. The cost of an outpatient therapy day includes bilirubin and laboratory costs. Because all newborns are assumed to have an outpatient visit with their primary care physician at some time within 2 weeks after hospital discharge and that some infants in each arm will require additional visits, the cost of these visits is not included.

**Statistical Analyses**

Comparisons of admission rates and ED visit rates between patients who had home nursing visits and those who did not were made using Fisher exact test.

**RESULTS**

**Patients, Home Nurse Visits, and Readmissions**

From January 2000 through December 2002, 2967 infants were discharged from the newborn nursery at the Hershey Medical Center (Table 2). A total of 326 (11.0%) infants were discharged with a scheduled home health nurse visit after discharge following a mean length of stay of 2.8 days. The 2641 infants that did not receive a visit had a mean LOS of 2.1 days. Two of 326 (0.6%) home-visited newborns were readmitted in the first 10 days of life compared with 73 (2.8%) of 2641 newborns who did not receive a home visit ($P = .0141$). The average LOS for the readmissions was 3.2 days. Forty-four (60.3%) of 73 infants who were readmitted required subsequent outpatient therapy.

**ED Visits**

Ninety-two (3.5%) of the 2641 infants who were not visited by a nurse returned to the hospital's ED in the first 10 days of life compared with none (0%) of those who did receive a nurse visit ($P < .0001$; Table 2). Twenty-one of the 92 infants who had ED visits were subsequently admitted to the hospital; 29 were discharged from the ED requiring outpatient phototherapy.

**Cost-Effectiveness of Routine Home Nurse Visits**

When the data for readmission and ED visits are combined, 99.4% of patients who received a home nursing visit required no additional hospital-based services in the first 10 days of life compared with 94.5% of patients with no visit ($P < .0001$). On the basis of the probabilities at this center and the average costs associated with each health state, the expected cost per child who received a home health visit was $109.80 compared with $118.70 for each newborn who did not receive a visit (Table 3). Therefore, the home nursing visit strategy is said to be dominant because it is both less costly and more effective. The ICER of a routine home nursing visit strategy compared with no visit was $-181.82$, which suggests that payers will save $181.82 for every additional child who does not use hospital services in the first 10 days of life.

Sensitivity analyses reveal that the routine home visitation arm remains the dominant strategy, both less costly and more effective as long as the average insurer reimbursement for inpatient stays and ED

**TABLE 1. Average Reimbursement From Payers**

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost, $</th>
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<tbody>
<tr>
<td>Inpatient day</td>
<td>1163.00</td>
</tr>
<tr>
<td>Inpatient stay</td>
<td>3722.00</td>
</tr>
<tr>
<td>ED visit</td>
<td>422.00</td>
</tr>
<tr>
<td>Home health visit</td>
<td>85.00</td>
</tr>
<tr>
<td>Bilirubin rental (1 d)</td>
<td>8.00</td>
</tr>
<tr>
<td>Bilirubin laboratory evaluation</td>
<td>4.00</td>
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</table>
visits remains >$3071.33 and $169.24, respectively (Fig 2 A and B). Routine visitation ceases to be the less expensive strategy when the costs of outpatient therapy and a home nurse visit increase to $399.12 and $99.91, respectively (Fig 2 C and D).

**DISCUSSION**

As described by the AAP, a follow-up visit within 48 hours of discharge from the newborn nursery serves several important purposes: (1) the infant’s general health, hydration, and degree of jaundice are assessed; (2) feeding can be observed and evaluated; and (3) parent-infant interaction and infant behavior may be observed. Because compliance with the timing of the guidelines is poor, alternative methods for outpatient care in the immediate postnatal period must be evaluated to ensure that infants are evaluated on the third or fourth day after delivery. This investigation proposes routine home nurse visitation in the 48 hours after hospital discharge and describes the effectiveness of home visitation for the prevention of hospital-based care for neonatal jaundice and dehydration as well as the costs associated with such an approach. Although this intervention is generally available in the United States and is the usual standard of care in many European countries, it is not routinely used in the United States, even when insurance coverage of a visit is mandated by law.

The data at this center demonstrate that home nurse visitation is associated with a significant reduction in the need for subsequent hospital and ED visits for jaundice and dehydration. These data also show that a program in which each infant receives a home visit may be less expensive to payers as a result of the reduction in the need for more expensive hospital-based services. Because these visits have been shown to occur in a more timely manner than scheduled outpatient physician visits, a home visit 1 to 2 days after discharge could in theory result in earlier recognition of and increased outpatient intervention for these 2 common conditions. Because of the increased utilization of ED nationally and because inpatient beds are a finite resource, particularly in the winter months, measures to reduce the need for these services would certainly be welcome. The results of this study are in agreement with those that describe a reduced need for hospital and emergency services when guidelines for primary care of infants are followed and accessibility of this care is improved.

Discharge earlier than 48 hours may result in a failure to recognize medical conditions that require intervention, such as jaundice, dehydration, ductal-dependent cardiac lesions, intestinal obstruction, seizures, and major infections. Early discharge has also been associated with increased infant mortality, although this is controversial. Two common, potentially harmful, yet preventable conditions that often present on the third and fourth day of life are jaundice and dehydration. These often comorbid conditions may not be apparent during the hospital stay but often occur soon after discharge. Despite the risk, many nurseries do not routinely provide verbal or written instructions about jaundice before discharge, even nurseries in which early discharges are more common. The presence of risk factors for jaundice also may not result in increased adherence to follow-up guidelines.

Social risk factors also may not be detected during a short hospital stay. Even if detected, postdischarge monitoring may not be sufficient. One study reported that obstetricians place little emphasis on social risk factors or demographic variables as determinants of the need for close follow-up of new mothers but rather place the emphasis on whether there is a medical need for follow-up. Home visitation clearly is a solution for this gap in care, allowing for an environmental and social assessment that cannot be equally accomplished at an office visit.

Because of these and other benefits, the American Nurses Association has advocated for the home visitation model of postpartum care as opposed to an initial outpatient postpartum visit at a medical facility. The American Nurses Association wrote that the outpatient model may be difficult for the healing mother, interrupts breastfeeding, and often does not allow ample time for health teaching and evaluation of family dynamics. They describe postpartum home care as “the preferred method of delivering necessary care for those patients who are discharged from the hospital while in the immediate recovery phase.” The AAP has also supported home visitation programs, describing them as an effective early intervention strategy for improving the health and well-being of children and has encouraged pediatricians to use home visits as a complement to office-based care.

Although supported by many nurses and physicians, little research has focused on the impact that 1 well-timed visit can have on health outcomes. The work that has been done suggests that it may be significant. Similar to our study, Braveman et al retrospectively discovered that acute care visits, rehospitalizations, and missed well-infant visits were less common among newborns who received a home nurse visit. In addition, Cooper et al reported earlier and more consistent follow-up at a primary care physician’s office with decreased ED utilization in a program of early discharge with home visitation when compared with a cohort that did not receive a home visit.

Other outcomes may also be affected. For example, the percentage of mothers who initiate and subsequently continue breastfeeding under a program of early discharge with a postnatal home visit within 48 hours was found to be equal to those in a program in
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Expected Cost</th>
<th>Incremental Cost</th>
<th>Expected Effectiveness</th>
<th>Incremental Effectiveness</th>
<th>ICER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home nurse visit</td>
<td>$109.80</td>
<td></td>
<td>0.9939</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No home visit</td>
<td>$118.70</td>
<td>$8.80</td>
<td>0.9455</td>
<td>-0.0484</td>
<td>$181.82</td>
</tr>
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Fig 2. Sensitivity analyses for average costs ($) of inpatient visits (A), ED visits (B), outpatient therapy (C), and home health visits (D).

which the majority remain in the hospital for 2 days or more. These visits have been found to be encouraging and helpful to a majority of women who attempt to breastfeed. Mothers also report improved confidence in parenting, satisfaction with health care delivery, and increased convenience of care after home nurse visitation. Nurses have a proven ability to detect significant jaundice, and some data suggest that these visits may reduce neonatal readmissions and ED visitation rates.

In addition to addressing medical needs, more attention seems to be paid to psychosocial problems by nurses at a postnatal visit than at a scheduled office visit. Minde et al recently audiotaped the first nurse and physician visits for 42 mother–infant pairs. This study found that nurses spent more time with families, discussed more psychosocial issues, and were rated to be more sensitive interviewers than physicians. Although the physicians seemed to be more concerned with maternal pregnancy complications, the nurses were rated to be more concerned about the psychological well-being and psychological difficulties of the mothers.

In addition to the cost-effectiveness described on the sole basis of prevention of neonatal readmissions and ED visits that are described in the current study, some direct and intangible costs that have not been included in this cost analysis may be saved. First, in the immediate postnatal period, there may also be a reduction in maternal health care costs as a result of nursing assessment and intervention at the home visit. Of note, a significantly reduced incidence of postpartum depression has also been described. Next, women who are visited in both the prenatal and postnatal periods tend to have improved knowledge about contraception, fewer subsequent pregnancies, and more time between subsequent pregnancies. Their infants also have fewer ED visits and unintentional injuries, ingestions, and poisonings.

Similarly, there is a reduced incidence of
child abuse and neglect in infants who participate in such programs.\textsuperscript{61,65,67} The relationship between home visitation and reduced child abuse and neglect led the US Advisory Board on Child Abuse and Neglect under the direction of the Department of Health and Human Services to recommend in 1991 that the federal government begin a national universal home visitation program for children during the neonatal period.\textsuperscript{68,69} In 2003, the US Centers for Disease Control and Prevention’s Task Force on Community Preventive Services echoed this recommendation on the basis of strong evidence of effectiveness.\textsuperscript{70} Home visitation has also been associated with a reduction in sudden infant death syndrome.\textsuperscript{71}

Central to the highly debated topic of newborn health care delivery is the presence of mixed data that both support and refute the necessity of the AAP recommendations. Critical reviews of the existing literature have revealed methodologic flaws in the majority of the earlier investigations,\textsuperscript{72-77} whereas some recent, better designed, and more powerful studies use data sets that do not precisely match the AAP 48-hour recommendation for discharge.\textsuperscript{35,37,42,76} As a result of data set limitations, the LOS is usually approximated. For example, Edmonson et al\textsuperscript{66} defined early discharge as being released from the hospital on the day of birth (day 1) or the next day (day 2). However, this method does not allow for the significant difference in LOS between infants who are born in the early morning versus late evening hours. It also excludes newborns who are discharged on day of life 3 and are still <48 hours old and range in age from 24.1 to 47.9 hours.\textsuperscript{72}

There are several limitations of this study. First, the primary outcome measure of readmission and ED-free days fails to address fully the impact of other important outcomes such as breastfeeding success, parental confidence, and convenience of care that are not included in the direct costs of the model. The value of these outcomes is difficult to quantify.

Second, this model does not describe the morbidity and mortality that may be caused by other, less common conditions, some of which may be costly to the payer and may or may not be detected by a visiting nurse. However, lack of compliance with the AAP guidelines most likely lends to a reduced recognition of these conditions. Because these conditions are rare, they were excluded from this analysis. Our model also does not include infants who may have been readmitted to or had an ED visit at another hospital. The frequency of this is thought to be low given the nature of this tertiary care center and its unique ability to serve the health care needs of children in this community.

Third, this was a retrospective analysis of newborn discharges that does not account for potential selection biases that may or may not lead to a home nurse visit. Although one might hypothesize that “at risk” infants might be more likely to receive a home visit, others might argue that those infants are more likely to receive an office visit by a primary care provider shortly after discharge. The current literature, however, does not support the argument that the presence of risk factors leads to earlier office visits.\textsuperscript{9} The timing of each of these visits may lead to another potential confounder, that of ascertainment bias.\textsuperscript{78} Increased visitation on the third or fourth day after delivery might lead to an increased number of infants receiving diagnoses of conditions such as jaundice and dehydration. Although this is possible for the current study, any potential ascertainment bias did not lead to an increase in the use of hospital-based services when studied retrospectively.

The longer nursery LOS for the newborns who received a home health visit is noteworthy. Although this difference is important to consider when interpreting the potential impact of home health visits, the current data still strengthen the evidence that routine assessment on the third or fourth postnatal day of life is effective in preventing subsequent neonatal morbidity. In contrast to the LOS results presented, it is theoretically reasonable that if infants are guaranteed a home health visit after discharge, then clinicians may be more comfortable discharging infants in a more timely manner. In fact, a reduction of the average LOS by ~4 hours would alone provide the cost savings to cover a home nurse visit.\textsuperscript{79}

Next, this model does not account for the potential reduction in non-ED, outpatient urgent care visits that have been reported when programs for neonatal follow-up have been standardized to meet recommendations.\textsuperscript{25,26,80} The newborn and infant outpatient visit recommendations potentially could also be adapted to reduce the number of total visits. This reduction would certainly make the routine nursing intervention even more cost-effective.

Finally, despite AAP guidelines on the management of neonatal hyperbilirubinemia, there is significant variability in the use of outpatient phototherapy, inpatient phototherapy, and the thresholds for treatment. Although the data from this center regarding readmissions, outpatient phototherapy, ED utilization, and costs of care may not be completely generalizable to all populations, the model created for this analysis is.

In conclusion, postnatal home nurse visitation seems to be a highly cost-effective intervention for payers on the sole basis of prevention of subsequent hospital-based services for neonates in the first 10 days of life. Although staffing issues could be an obstacle for an already stressed nursing labor force and other professionals may be required, implementation of routine visitation has been shown to be possible abroad and in select communities in the United States.\textsuperscript{81,82} A home visit has the ability to improve compliance with the AAP guidelines for follow-up of the neonate after hospital discharge, reduce the morbidity associated with common conditions that present in the postnatal period, and, most important, improve overall quality of care for newborns and their parents.

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