

## Telenursing Service for Neonatal Post-discharge Home Care

Valentina Isetta  
University of Barcelona - CIBERES,  
Faculty of Medicine  
Unit of Biophysics and Bioengineering  
Barcelona, Spain  
valentina.isetta@ub.edu

Carmen Lopez-Agustina  
Hospital de Sant Pau  
Neonatal Home Care Program  
Barcelona, Spain  
clopez@santpau.cat

Montserrat Vila  
Hospital de Sant Pau  
Supervisor of Neonatal Intensive Care Unit  
Barcelona, Spain  
mvila@santpau.cat

Asunción Clemente  
Hospital de Sant Pau  
Head of Pediatric Nursing Section  
Barcelona, Spain  
aclemente@santpau.cat

Meritxell Cucala  
Hospital de Sant Pau  
Innovation & Projects, Nursing Direction  
Barcelona, Spain  
mcucala@santpau.cat

Ramon Farré  
University of Barcelona - IDIBAPS - CIBERES,  
Faculty of Medicine  
Unit of Biophysics and Bioengineering  
Barcelona, Spain  
rfarre@ub.edu

**Abstract**—The application of Information and Communication Technology (ICT) in nursing care is becoming more widespread but few examples have been reported in neonatal care. The post-discharge period of sick newborns from a Neonatal Intensive Care Unit (NICU) is a challenging time for young families. Neonatal Home Care Programs offer home support after discharge but clinical and geographical constraints render this service inaccessible to many families that could benefit from it. This paper describes a new web-based application that provides online monitoring of babies after discharge from a NICU. By accessing to a personal area on the website, parents are asked to periodically answer a questionnaire about the newborn's health status (weight, feeding, sleep, etc.). The answers are continuously monitored by professional nurses, who can communicate online with parents to advise them about good baby care. Moreover, high-quality informative documents of use to babies' families are available online. The aim of this tool is to ease pressure on the healthcare system from additional visits, reduce hospitalization and improve parents' satisfaction. The results of a usability test with potential users are shown.

**Keywords**—eNurse; neonatology; telemedicine; home monitoring.

### I. INTRODUCTION

The pressure to contain health costs, particularly by avoiding hospitalizations and promoting the early discharge of patients, is generating a greater demand for home healthcare at a time when this resource is rapidly

becoming less available. Telemedicine involves the use of information technology that facilitates communication between patients and healthcare professionals. This technology has been increasingly considered to potentially have a key role in closing the gap between the demand for and availability of home healthcare services [1].

In the last decade, the telemedicine concept has been expanded to nursing care because it can provide efficient, long-distance healthcare. Telenursing offers easy access to high-quality care and reduces the costs and problems related to travel to health facilities. Patient satisfaction with telenursing is based on prompt, expert care from professional nurses that enhances patients' involvement in their own care and strengthens the nurse-patient relationship [2]. Most nurses recognize the contribution that Information and Communication Technology (ICT), and in particular the Internet, can make to their practice and their patients' understanding of their health and care [3]. Telenursing is progressively becoming more extended as a valuable technique for delivering nursing care, particularly in home healthcare.

Examples of telenursing applications include the use of different telecommunication tools, particularly the telephone and, more recently, the Internet. Telephone triage is already a well-established application in many clinical fields, allowing nurses to determine whether the caller is in need of healthcare and, if necessary, refer him/her to the proper care source [4][5]. In order to provide a health service built around patients' needs, including the need for knowledge and information, the Internet is increasingly preferred over the telephone. A



Figure 1. eNHCP home page screenshot. Translation from original version in Catalan: *Header*: “Babies at home”. *Menu-bar*: “Home”, “Tips for baby care”, “Useful links”, “Online baby follow-up”, “About us”. *Content*: ” Congratulations, parents, and thank you for your visit to ‘Babies at home’! You as parents, and we as health professionals, know that the most important thing is the health of your children. From the Neonatal Unit at the Hospital de la Santa Creu i Sant Pau we have created a page where the babies are the stars and you will find tips, links and answers to frequently asked questions regarding baby care. Use the menu to navigate to different sections of the website.”, “Project developed with the collaboration of the Unit of Biophysics and Bioengineering, Faculty of Medicine, University of Barcelona.”

pilot experiment with a Nurse-led Web Chat Triage produced positive reactions from patients [6]. Web-based tools for the support of chronic disease management, such as dyspnea in COPD patients [7], or for educational intervention, such as Web-assisted tobacco control [8], are recent examples of successful telenursing applications using the Web.

Neonatal care is a field where telenursing could be an interesting support tool, but there have been only a few studies to date. The admission of a newborn into a Neonatal Intensive Care Unit (NICU) and the period just after the discharge pose emotional, educational, and logistic problems for a parent. Young families without experience in critical care medicine need not only high-quality medical care but also effective and resourceful information sharing with health professionals.

One previous study described a program in which nurses provided updates to family members of NICU patients on the Internet [9]. The authors reported significant improvements in family satisfaction with NICU in-patient very low birth weight (VLBW) care and pointed out the need to extend this service to the post-discharge period. Programs of neonatal post-discharge home assistance, or transitional care, are already established in many neonatal departments. Typically, they provide in-

home and telephone support delivered by clinical nurse specialists for a period after infants are discharged. Wide-ranging program evaluations have revealed a decreased demand in health care resources (mainly emergency departments and pediatricians’ consulting rooms) and improved maternal confidence and satisfaction with community service [10]. However, this kind of service is expensive and difficult to maintain with the resources currently available to public health. Therefore, it would be of great interest to have a support tool which can establish a direct contact between parents and NICU staff after baby’s discharge, increase parental involvement in baby’s care as well as guarantee the cost-effectiveness.

In 2004, the Hospital de la Santa Creu i Sant Pau (HSP) of Barcelona launched the Neonatal Home Care Program (NHCP), which provides home assistance delivered by neonatal nurses and has demonstrated its effectiveness in reducing hospitalization and increasing users’ satisfaction. The NHCP established clinical criteria and a maximum distance from a patient’s home, which necessarily limit the number of patients that can be included. To overcome these geographical and clinical limitations of the NHCP, the HSP Neonatal Care Department decided to expand it, implementing the eNHCP, an Internet-based support and monitoring



Figure 2. eNHCP “Online baby follow-up” page screenshot. By logging in, parents can access to their exclusive area. Nurses and healthcare professionals can access to their special area by clicking to the link in the lower right corner of the page. Translation from original version in Catalan: *Header*: “Babies at home”. *Menu-bar*: “Home”, “Tips for baby care”, “Useful links”, “Online baby follow-up”, “About us”. *Content*: “Online baby follow-up. Access to this section is exclusively for parents registered to the online baby follow-up service.”, “Login. Your e-mail address. Your password. Enter.”, “Forgot your password?”, “Healthcare professionals”.

program for newborn patients after discharge. The application developed essentially comprises a web service managed by the NHCP nurses, which provides high-quality educational information about neonatal care to new parents and baby monitoring through a survey that parents fill in periodically. The aim is to relieve the pressure on the healthcare system caused by additional visits, reduce hospitalization and enhance parents’ empowerment and satisfaction.

The eNHCP web tool, described in detail in this paper, was developed in close collaboration with the Unit of Biophysics and Bioengineering, Faculty of Medicine, University of Barcelona. A preclinical validation of the tool was performed by a usability validation test with potential users, the results of which are shown.

## II. TOOL DESCRIPTION

The web tool was implemented using PHP language and MySQL database on a Linux/Apache server. All user interface components were developed as dynamic server-side pages. Javascript components were implemented in order to enforce completion and internal consistency of all forms and questionnaires contained in the web tool.

The application was developed with a focus on usability and structure simplicity. In each development

stage, special efforts were made to guarantee the maintainability and versatility of the tool. The system architecture was designed to allow frequent updating of the individual pages and easy adaptability to different clinical applications.

The web application functioning was successfully tested with the most important operating systems and web browsers.

The application consists of three main areas:

- Free-access area;
- eNHCP Parents Area;
- eNHCP Staff Area.

### A. Free-access Area

This area is an open platform that all parents can freely access to find useful information about newborn care. A screenshot of the home page is shown in Figure 1.

The top menu bar contains the links to the different sections of the website. The main sections are:

- “Tips for baby care”, which contains several informative documents available for free download written by the NHCP nurses and pediatricians. These documents contain helpful advice about newborn care, such as feeding, bathing, sensory stimulation, massage, how to avoid hazards, primary care, when to go to the

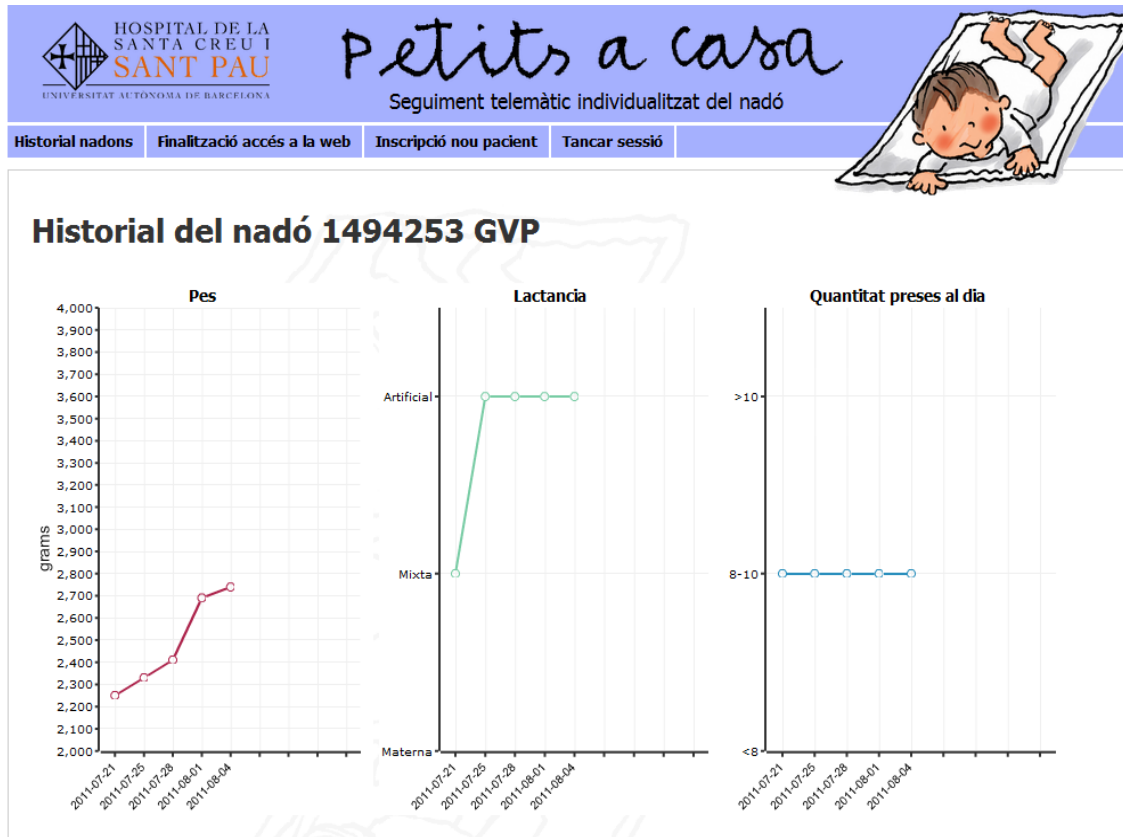


Figure 3. eNHCP nurse page screenshot. Visualization of parents' answers to the periodic questionnaire by dynamic Flas charts. Translation from original version in Catalan: *Header*: "Babies at home. Online baby follow-up". *Menu-bar*: "Baby record", "Deregister a baby", "Register a baby", "Log out". *Title*: "Data of baby number...". *Graphs*: "Weigth", "Feeding", "Intakes per day".

pediatrician, etc. Instructive videos are available in the multimedia section;

- "Useful links", where parents can find a comprehensive list of breastfeeding and neonatal nursing association websites;
- "Online baby follow-up", where parents and nurses can access, after authentication, their respective restricted areas of the eNHCP website (see Figure 2). By clicking on the link "Forgot your password?" users can retrieve their password, which will be automatically sent to their e-mail address.

### B. eNHCP Parents Area

Once their eligibility has been established, parents are informed about the web tool and their informed consent is obtained. In order to guarantee the confidentiality of all patients and preserve security, parents included in the eNHCP can access this private area by logging in with their personal username and password, assigned by the NHCP nurse during the enrollment. The eNHCP web tool identifies the user and dynamically generates pages containing only the information available to each user.

In this section all parents find a periodic questionnaire formulated by the NHCP nurses about the baby's conditions (weight, feeding, sleeping, body temperature, skin color, etc.). It comprises 18 questions covering the essential topics that NHCP nurses usually investigate and assess during home visits. The questionnaire has been carefully designed to be autonomously answered by parents, who are recommended to respond it every four days. Their answers are stored, together with the patient authentication data, in a relational data base developed with the MySQL management system. All data are stored in the secure environment of the hospital server.

Furthermore, the baby's weight trend is plotted and continuously updated on the basis of the periodic questionnaire answers. This section was created in order to give parents a visual feedback of their baby's progress.

Another important function integrated into the website is the possibility of exchanging messages via e-mail with the eNHCP nurses, in order to clarify doubts and answer questions about baby care. In the same way, parents can make direct contact with the Webmaster, who is available to solve potential technical problems related to the website's functioning.

### C. eNHAP Staff Area

By clicking on the link “Professionals” (see the lower right corner of the screenshot of Figure 2), the eNHCP nurses and pediatricians can enter their own authentication page, similar to that of the parents (as shown in Figure 2). By logging in, they can access the special staff area, where they can undertake three main management activities:

- Monitoring eNHCP babies’ status. In this section the eNHCP patients list is displayed and, by selecting one, nurses can observe a baby’s data corresponding to parents’ answers to the periodic questionnaire. Data are retrieved from the MySQL database and shown in dynamic Flash charts (see Figure 3). After the baby’s data evaluation, nurses can, if necessary, write a message directly to the parents with advice and comments about the newborn’s care;
- Registering a new baby on the eNHCP. Nurses have to fill in a simple form with the identification data for each baby, such as his/her electronic health record number, name initials and contact e-mail address. The parents of twins or triplets are asked to provide an e-mail address for each baby. In order to protect the newborns’ personal information, the baby’s name and surname are not included on the registration form. When the registration is complete, a “welcome” e-mail is sent to the contact e-mail address with the parents’ credentials needed for authentication by the web tool. The username is the contact e-mail address and the password is automatically assigned, with the possibility of changing it at anytime;
- Deregistering a baby when he/she meets the clinical criteria for final discharge. In order to obtain feedback of users’ acceptance of the eNHCP web tool, a concluding satisfaction survey is automatically sent to the parents just after the deregistration. Parents’ answers are automatically sent via e-mail to the eNHCP e-mail box to be evaluated by the nurse; they are also stored in the MySQL database to be available for further analysis.

### III. PRE-CLINICAL VALIDATION

Before being introduced into routine clinical use, the web tool described above was assessed by a usability test with potential users, in accordance with the UNE-EN 62366 rules. This standard, entitled "Medical devices - Application of usability engineering to medical devices", defines the process of development and testing that should be followed to identify and validate the usability features of a medical device with respect to its security and normal use. Specifically, the aim of this test was to assess the opinion of potential users on the usability and usefulness of the web tool.

A questionnaire similar to the final satisfaction survey proposed on the eNHCP site was given to 15 parents of patients admitted to the HSP NICU. An NHCP nurse had already explained them the eNHCP concept by showing them a website prototype.

The survey comprised 8 statements about the usefulness of the eNHCP contents and functions, and possible answers were distributed on a scale from 0 (I strongly disagree) to 5 (I strongly agree). The results are shown in Table 1. The potential users showed a level of agreement of  $4.67 \pm 0.49$  (mean  $\pm$  SD) to the first statement, corresponding to an overall positive evaluation of the helpfulness of the eNHCP website.

### IV. CONCLUSION

The web tool described in this paper represents a cheap and straightforward approach to support home healthcare. Its application to neonatal care opens up new horizons in the follow-up of NICU patients after discharge. Besides providing high-quality educational contents about neonatal care to parents, the novelty of this tool resides in offering to nurses a valuable and easy procedure for the home monitoring of newborns, as well as fast long-distance communication with families. Furthermore, the questionnaire periodically answered by parents is a monitoring approach which promotes a higher involvement of parents in their baby’s care and, consequently, enhances their care skills and self-confidence during a usually stressful period such as the one of post-discharge from NICU.

The concept of this tool as an interactive website is a very convenient method, due to the wide availability of

TABLE I. USABILITY TEST WITH POTENTIAL USERS

Survey statement	Answer (mean $\pm$ SD)*
1. In general the Web service "Babies at home" could be helpful.	4.67 $\pm$ 0.49
2. The available information could help me take care of the baby.	4.27 $\pm$ 0.80
3. The information available on the website could clarify my doubts.	4.00 $\pm$ 0.76
4. The e-mail service with nurses available on the website could be useful.	4.37 $\pm$ 0.76
5. The files and recommended links could be useful.	4.07 $\pm$ 0.70
6. The use of the website could avoid visits to the primary care center.	4.47 $\pm$ 0.64
7. The use of the website could avoid visits to the emergency department.	3.87 $\pm$ 0.64
8. I would recommend this website.	4.67 $\pm$ 0.49

\*0 = I strongly disagree, 5 = I strongly agree.

Internet-connected computers among healthcare consumers, especially in the homes of young families. Moreover, as usability and structural simplicity were crucial to the development of the application architecture, the training required by nurses and parents is minimal. Concerns about security and personal data confidentiality have been minimized, as this kind of application can be easily incorporated into the secure environment of a hospital server.

By using this tool, well-established neonatal home care programs could be effectively integrated, reducing costs and overcoming clinical and geographical limitations. Its routine use would be expected to reduce visits to primary and emergency care centers resulting from lack of information and insecurity on the part of parents, thereby improving the cost-effectiveness of the NHCP service.

Given the highly positive reactions obtained from the usability test with potential users, in July 2011 the website started to be used as part of a pilot test with real patients. At the end of pilot period the impact of the eNHCP web application will be formally assessed in terms of cost-effectiveness and users' (both parents and NICU staff) satisfaction.

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