Review

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Information and communication technologies in neonatal health

Pablo Duran[1], Janine A. Sommer[2], Paula Otero[2], Mariana Daus[2], Sonia Benitez[2], Suzanne Serruya[1] and Luis Andres De Francisco[3]

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ABSTRACT

Objectives. To identify scientific evidence on the use and results of information and communication technologies for the improvement of neonatal health in general or specific health problems or interventions, and to describe the type of intervention and its results.

Methods. A systematic review of the available evidence was performed. The search was carried out in peer-reviewed journals between January 1, 2008 and April 30, 2018, in English and Spanish. The searched key terms were (health informatics OR telemedicine OR mHealth) AND (newborn OR newborn care OR neonatal care).

Results. From a total of 305 articles initially identified, 10 articles fulfilled the inclusion criteria. The main domains of eHealth identified as applied to neonatal health were telemedicine (3 studies), eLearning (1 study) and mHealth (7 studies). Target population were health care providers or parents. The studies aimed at diagnosis, provision of health care and training, promoting adherence to interventions in parents or improving quality of care.

Conclusions. The use of eHealth in general and specifically focused on neonatal health shows important possibilities for development and expansion, given the advances and present needs, and should be considered a key tool for the reduction of inequalities.

Keywords Information technology; infant health; evidence-based medicine; perinatal care; eHealth strategies; telemedicine.

It has been proposed that information and communication technologies (ICTs) applied to health and healthcare systems can increase their efficiency, ultimately improving people's quality of life (1–4).

eHealth is the use of ICT in health products, services and processes combined with organizational change in healthcare systems and new skills, in order to improve the health of individuals, efficiency and productivity in healthcare delivery, and the economic and social value of health. eHealth covers the interaction between patients and healthcare providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and/or health professionals (5).

eHealth applications contribute to progress towards universal health coverage and its goals (6). The Strategy for Universal Access to Health and Universal Health Coverage (7) calls for addressing barriers especially for vulnerable groups, including mothers and their newborns. During the past two decades, important progress in child survival has been made and, at present, neonatal mortality is the main component. The risk of dying was highest in the first month of life, at an average rate of 18 deaths per 1,000 live births globally in 2018 (8).

There are important limitations in the implementation of evidence-based interventions in newborn health from both the global and regional perspective. Conversely, the potential impact on reducing perinatal mortality due to preventable

[1] Pan American Health Organization/World Health Organization, Montevideo, Uruguay ✉ Pablo Duran, duranpa@paho.org

[2] Hospital Italiano de Buenos Aires, Buenos Aires, Argentina

[3] Pan American Health Organization/World Health Organization, Washington DC, United States of America

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causes linked to such interventions is estimated as important (9). Evidence has shown that health care provided around the time of birth saves mothers and their newborns and prevents stillbirths and disability. Evidence on best practices and strategies that broaden the coverage of interventions for newborns, reducing mortality, morbidity and disabilities has been accumulating over recent decades. Innovative thinking aimed at increasing the participation of all stakeholders and reaching the poorest and most underserved populations is needed, as well as more research and development to optimize the application of knowledge of which interventions and strategies are most effective (9).

There are efficacious, cost-effective interventions that can prevent these deaths, including stillbirths. However, these interventions are not universally accessible across Latin America and the Caribbean (9,10).

eHealth has the potential to enable a positive transformation in the delivery of healthcare, making it safer, more effective and efficient. In different organizations the implementation of interoperable health information systems built around an electronic health record has shown gains. However, as the implementation of health informatics is not widespread yet, only few health organizations have shown the improvement of care and management of costs. There is a need for further expansion and experiences on implementing eHealth and evaluating results at a local, national and regional level (2).

Global and regional strategies and plans of action promote investment in building country capacity, linking evidence to policy and practice and testing and scaling up innovations in order to achieve the objectives of reducing preventable deaths, ensuring health and wellbeing and expanding enabling environments among women, newborns, children and adolescents (11,12).

Knowledge and technological advances are recognized as important as economic resources in improving health and well-being, and innovation is considered as a starting point for translating evidence into practice (13).

In Latin America and the Caribbean, considerable inequities persist in access to health services due to a number of factors that limit the possibilities of receiving timely quality health care. Conditions such as income level, geographical location and ethnicity, among others, are determinants of health and disease and of important inequities in the Region of the Americas (14).

In contrast to inequities in access to quality health care and specific interventions and their outcomes, access to ICTs may be less inequitable (9). There is a need to analyze the inequities in access to technology in contraposition to other aspects, and to discuss the possible impact of the use of information technology to facilitate information access for the general population as well as for healthcare teams.

The purpose of this review is to assess the availability of evidence on how health informatics applications can help to provide better care for newborns, and to address the knowledge gap and the lack of significant literature accounting for the use of ICTs in neonatal health and evidence-based interventions. The objective is to identify scientific evidence on the use and results of ICTs for the improvement of neonatal health –in general or oriented to specific health problems or interventions– and to describe the type of intervention and its results.

METHODS

A review of current available evidence on the use of ICTs in neonatal health and evidence-based interventions was performed. Studies were included if published in academic, peer-reviewed journals between January 1, 2008 and April 30, 2018 with full-texts in English or Spanish; were conducted in humans; and included original research presenting results on the use of ICTs in neonatal health. Studies describing a prototype, a pilot experience or future research were excluded. The search was conducted during May 2018 in MEDLINE using PubMed, LILACS and Google Scholar. The US National Library of Medicine's Medical Subject Headings (MeSH) were used; specific key terms were health informatics, telemedicine, mHealth, newborn, newborn care, and neonatal care.

Three reviewers performed the search, data extraction and analysis. Data was organized according to study design, target population, type of ICT included, results and limitations.

After removing duplicates, the reviewers independently reviewed the abstracts. Papers were assigned to reviewers, who then recorded independent observations. Reviewers were asked to record any overarching themes that seemed to serve as a common thread between studies, as well as any significant levels of bias that could have been present in each one. The papers were assessed by the relevance of each abstract in a spreadsheet, and those assessments were later combined during a consensus meeting; discrepancies were solved through discussion of the documented exclusion criteria.

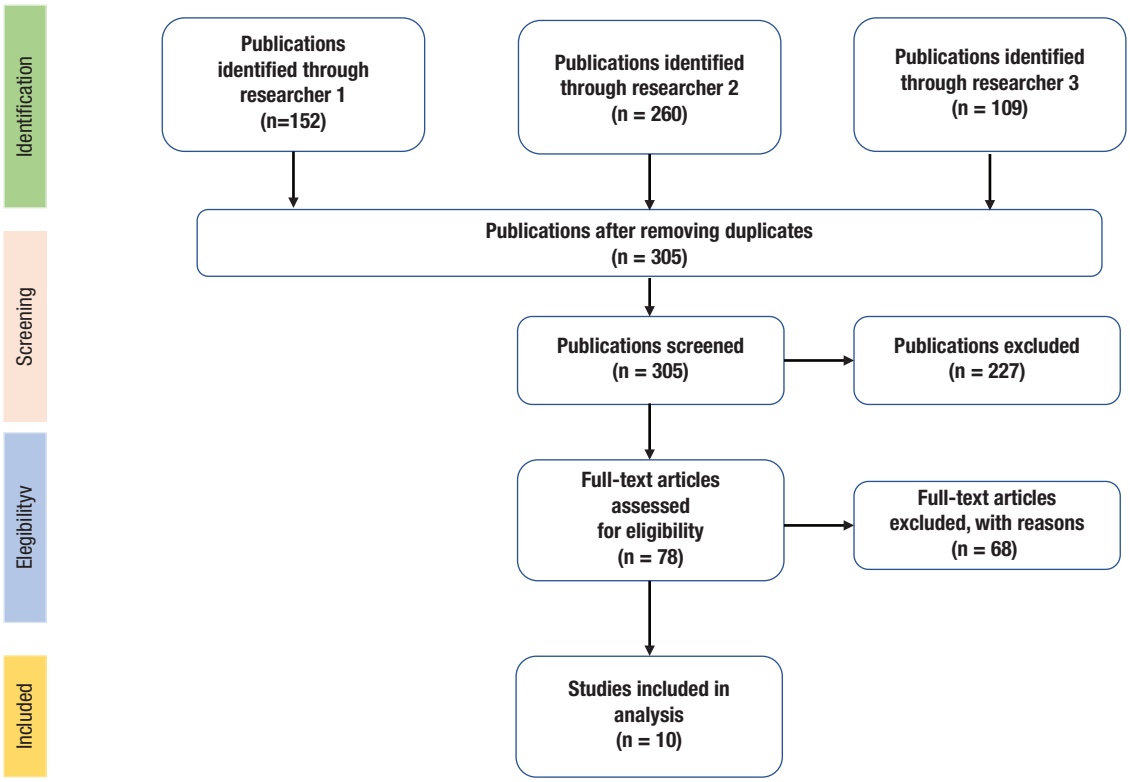
In a second round, the reviewers evaluated the full text to determine the final eligibility based on inclusion criteria and articles categorized; they then grouped their observations in logical manner based on the eHealth components described in PAHO´s eHealth Strategy and Plan of Action 2012-2017 (15). The components were: electronic medical records (i.e., real-time longitudinal electronic record of an individual patient's health information that can aid health professionals with decision-making and treatment), telehealth (i.e., access to healthcare services using ICTs, specifically where distance is a barrier), mHealth (i.e., delivery of medical or healthcare practice using mobile devices), eLearning (i.e., continuing education in information and communication technologies that implies the use of ICTs for learning, not only to improve the quality of education, but also to guarantee accessibility to educational materials, innovative ways of training and to amplify delivery to more people), and standardization and interoperability (i.e., communication between different technologies and software applications for the proper sharing and use of data based on the use of standards).

Additionally, each reviewer examined the references of each paper to identify any relevant papers that the initial search might have missed; in case of disagreement, reviewers discussed the observations and reached a consensus. One member (SB) of the team served as facilitator.

RESULTS

From a total of 305 articles initially identified, 295 were excluded for not addressing the use of ICTs in neonatal health. Ten articles fulfilled the criteria defined and were analyzed (Figure 1). Table 1 describes the main characteristics of the 10 studies analyzed.

FIGURE 1. Article search and selection process



Following the classification criteria defined, based on PAHO´s eHealth Strategy and Action Plan (16), the eHealth components identified were: telehealth, which was present in 3 papers (17–19); 7 studies included mHealth interventions describing different experiences (17,18,20–25), and finally eLearning (1 paper) (26). All the studies, except one (17), were randomized controlled trials.

The target population were health care providers (17,22,23,26) or parents (18–21,24,27). The studies aimed at diagnosis (17), provision of health care (18,19) training (26), promoting adherence to interventions in parents (20,21,27) or improving quality of care (22–24) .

Studies included in the telehealth component involved one focused on its use on evaluation of acute phase of retinopathy or prematurity (ROP) by comparing remote evaluations of digital images to the findings of indirect ophthalmoscopic examination performed by experienced ophthalmologists (17), one study evaluating the impact of an enhanced telemedicine system on glucose control and newborn outcomes in women with gestational diabetes mellitus (18), and one study evaluating the impact of an intervention combining telephone contact compared to standard care on woman and infant postnatal care (19).

Studies addressing the mHealth component included one that combined videoconferencing and telephone contact compared with standard care, also included in the telehealth component (18); two studies analyzing the impact of text message reminders for immunization of infants (20,21) and four studies analyzing the impact of different interventions on improving quality of care. Three studies were focused on improving quality of care from providers: one evaluated the impact of a decision support tool on adherence to a neonatal resuscitation algorithm (22), one evaluated the effect of an app on perinatal survival and on health care workers knowledge and skills on neonatal resuscitation (23), and one evaluated a mobile phone intervention on skilled birth attendance and the impact in the newborn (24). An additional study aimed to analyze the effectiveness of two mHealth interventions (emails, text messages and short videos) on improving infant safe sleep practices.

The studies included in this review showed differences in relation to the results achieved. Adequate results were observed in the study applying telehealth in the evaluation of acute-phase ROP (17). Remote grading of images of an eye at a single session had 81.9% sensitivity and 90.1% specificity. When both eyes were considered for the presence of referral warranted-ROP, sensitivity increased to 90.0%, with 87.0% specificity. Sensitivity was directly associated with the quality of the remote images. Sensitivity of acute phase ROP detection decreased with increasing birth weight when diagnostic examination first identified findings consistent with acute phase ROP. Similarly, the studies applying telemedicine on improving adherence and quality of prenatal care in women with gestational diabetes mellitus (18) and in women and infant postnatal care (19) showed positive results. Homko et al. (18) evaluated the impact of a web-based, nurse-coordinated communication system composed of a secure internet server, an interactive voice response (IVR) telephone system and a database. No significant differences between telemedicine and standard control groups were reported on maternal blood glucose values or infant birth weight, gestational age at delivery, Apgar scores

TABLE 1. Characteristics of the 10 studies included in the review (population, design, study/intervention, results and limitations)

Study	Design	Population	Study intervention	Results	Limitations
Validity of a telemedicine system for the evaluation of acute- phase ROP Quinn GE et al. 2014 (17)	Observational study	**n = 1257** infants with birth weight (BW) <1251g	Regularly scheduled diagnostic examinations by an ophthalmologist compared with digital imaging by non-physician staff using a wide-field digital camera.	1257 infants (mean BW 864g, mean gestational age 27 weeks) underwent a median of 3 sessions of examinations and imaging.	• Difficulty of comparing image grading results to a criterion standard with known inherent variability.
			Ophthalmologists documented whether an eye met criteria for RW-ROP, i.e. zone I ROP, stage 3 ROP, or plus disease.	Diagnostic examination identified RW-ROP in 18.2% of eyes (19.4% of infants).	• Limited enrollment to infants at high risk i.e. <1251g BW, and may not be generalizable to all infants eligible for ROP examinations
			A standard 6-image set per eye was sent to a central server and graded by two trained, masked, non-physician readers.	Remote grading of images of an eye at a single session had sensitivity of 81.9% (95% confidence interval (CI): 77.4–85.6%) and specificity of 90.1% (95% CI: 87.9–91.8%).	• Was not designed to assess the time to reporting results to the clinical center or to provide rapid feedback requesting additional images when image quality was poor
			A Reading Supervisor adjudicated disagreements.	When both eyes are considered for the presence of RW-ROP, as would routinely be done in a screening, the sensitivity was 90.0% (95% CI 85.4–93.5%) with specificity of 87.0% (95% CI 84.0–89.5%), negative predictive value 97.3% and positive predictive value 62.5% at the observed RW-ROP rate of 19.4%.	• The availability of ROP specialists, licensing and liability issues must be dealt with, as well as establishing a consistent and reliable reading center. Procedures to address poor image quality are needed
Impact of a Telemedicine System with Automated Reminders on Outcomes in Women with Gestational Diabetes Mellitus Homko CJ et al. 2012 (18)	RCT	**n = 80** women 18 to 45 years, with gestational diabetes mellitus (GDM); 33 weeks of gestation or less at enrollment	An Internet-based telemedicine system was used to also allow interactive telephone voice communication between patients and providers and to provide automatic reminders to transmit data.	There were no significant differences between the two groups (telemedicine vs. controls) in regard to maternal blood glucose values or infant birth weight.	• Short period of the intervention (2 months)
			Women with GDM were randomized to the telemedicine group (n = 40) or to the control group (n = 40) and were asked to control their blood glucose levels four times a day.	Adding telephone access and reminders increased transmission rates of data in the intervention group compared with the intervention group in our previous study (35.6±32.3 sets of data vs.17.4±16.9 sets of data; P<0.01)	
			The women in the intervention group transmitted these values through the telemedicine system, while the women in the control group maintained paper registration journals, which were reviewed at prenatal visits.	No significant differences between the two groups with regard to birth weight on univariate or multivariate analysis (after controlling for gender, parity, prepregnancy BMI, and treatment), gestational age at delivery, 1- and 5-min Apgar scores, and rates of large for gestational age.	• Relatively small sample size
			The primary outcomes were the weight of the newborn and the control of maternal glucose. The data collection included blood glucose records, transmission rates for the intervention group and review of charts.	Eleven newborns required admission to the neonatal intensive care unit, but there were no perinatal/neonatal deaths.	• The neonates from the intervention group were born 0.7 week later than control group
			The primary end points in this trial were maternal glucose control and infant birth weight.	Women using the Internet sent in significantly more transmissions than did women using the phone/IVR system (42.8 – 32.4 vs. 10.9 – 16.3 data sets; P = 0.007).	• One could postulate that these differences in neonatal outcomes may have reached statistical significance with a larger sample size
			Secondary end points included pregnancy outcomes (mode of delivery, gestational age at de- livery, neonatal intensive care unit admission, Apgar scores, and rates of large for gestational age, and other neonatal morbidities) and system use.	In summary, our enhanced telemedicine monitoring system increased contact between women with GDM and their healthcare providers but did not impact upon pregnancy outcomes.	

(*continued*)

TABLE 1. Characteristics of the 10 studies included in the review (population, design, study/intervention, results and limitations) (*continued*)

Study	Design	Population	Study intervention	Results	Limitations
Efficacy of a videoconferencing intervention compared with standard postnatal care at primary care health centres in Catalonia Seguranyes G et al. 2014 (19)	RCT	1598 post partum women with Internet access attending eight 'Attention to Sexual and Reproductive Health units at Primary Health Care centres	At each of the eight units, 100 women were randomly assigned to the intervention group and 100 to the control group. Women in the intervention group could consult midwives by videoconference or telephone and could also receive standard care. Women in the control group received standard care from midwives at their health centres or at home.	1401 women studied; 683 in intervention and 718 in control group. Two hundred and seventy-six women (40.4%) used videoconferencing or telephone in the intervention group.	• Differences in the competencies of the midwives in the two countries
			Main outcome variables: number and type of visits, reasons for consultation, type of infant's feeding at six weeks and mothers' satisfaction with the care provided. Additionally, sociodemographic and obstetric characteristics, number of visits, number of visits involving online consultation and technology used.	Mean total visits, virtual and face-to-face, was higher in intervention group than in controls (2.74 versus 1.22). Women in the intervention group made fewer visits to the health centre (mean=1) than CG women (mean=1.17). Both differences were statistically significant ($p<0.001$ and $p=0.002$ respectively).	• The information on the visits made by women to emergency services in hospitals and to pediatric outpatient clinics at health centres was only collected via direct self-reports
				Prevalence of breastfeeding was similar in the two groups (intervention 64.5%, and control 65.4%). Mean overall satisfaction of women with midwife care was very high in both groups (intervention 4.77/5, control 4.76/5).	• The videoconferencing is only available for Internet users.
Vaccines4Kids: Assessing the impact of text message reminders on immunization rates in infants Niederhauser V et al. 2015 (20)	RCT	**n = 57** mothers or fathers	Parents in the intervention arm received standard notification – an appointment card at the previous appointment– plus reminder text messages 7 days before their child's immunizations which were due at 2, 4 and 6-months of age. Text messages were sent using a computer-based software program that connected to a cellular phone to send text messages. Parents in the control arm received standard notification of immunizations due only. Each participant was enrolled for seven months.	There were no significant differences in immunization rates between groups at 7 months of age.	• The text messaging service provider was accurate with the dates of the text messages for almost of the time
			Text messages immunization reminders sent 4 weeks prior and 2 weeks prior to the due date for the infant's 2, 4, and 6 month vaccinations. Main outcomes were barriers and immunization rates between groups	Overall immunization compliance at all measurement intervals was low, and as the infants got older, there was a decrease in immunization compliance rates. A higher percentage of experimental (58.8%) than control (34.8%) were not UTD at 7 months.	• More parents in the intervention group did not complete the study • There was loss of follow-up of 39% of the experimental group compared to a loss of 10% of the control • Small size of the sample
Feasibility of a randomized controlled trial to evaluate Text Reminders for Immunization Compliance in Kids (TRICKs) Ahlers-Schmidt CR et al. 2012 (21)	Pilot RCT	**n = 90** parents of newborns	Text message immunization reminders prior to immunization due dates. Participants received a $20 gift card at the time of enrollment. Parents in the intervention group also received a $20 gift card for completing the post-intervention interview. Outcomes: rate of immunizations, and rate of immunizations on time.	Greater numbers of intervention children received immunizations and were "on time" using per protocol analysis; though not statistically significance. However, post-intervention interviews (N=18) indicated strong support for TRICKs; 83% found the text message reminders very helpful and 17% somewhat helpful.	• Small size of the sample • Loss of phone service at 7 months for 40% of intervention parents • Problematic text messaging software

(*continued*)

TABLE 1. Characteristics of the 10 studies included in the review (population, design, study/intervention, results and limitations) (*continued*)

Study	Design	Population	Study intervention	Results	Limitations
Impact of a novel decision support tool on adherence to Neonatal Resuscitation Program algorithm Fuerch JH et al. 2015 (22)	RCT	**n = 65** Healthcare professionals with a current Neonatal Resuscitation Program (NRP) card were randomized to the control or intervention group and performed three simulated neonatal resuscitations.	Each subject participated in three standardized simulated neonatal resuscitation scenarios (A, B, C) presented in random order. Primary outcomes included percent adherence to the NRP algorithm in providing Positive Pressure Ventilation (PPV) and Chest Compression (CC) when clinically indicated, and the frequency of fraction of inspired oxygen (FiO_2) adjustments.	Sixty-five healthcare professionals were recruited and randomized to the control or intervention group. Positive pressure ventilation was performed correctly 55-80% of the time in the control group vs. 94-95% in the intervention group across all three scenarios ($p<0.0001$). Chest compressions were performed correctly 71-81% of the time in the control group vs. 82-93% in the intervention group in the two scenarios in which they were indicated ($p<0.0001$). FiO_2 was addressed three times more frequently in the intervention group compared to the control group ($p<0.001$)	• Pilot study; Subjects did not serve as their own controls • The focus of this study was limited to decision-making, and did not include evaluation of other cognitive, technical or behavior skills • This study was performed in a highly standardized simulated delivery room environment, not on real ambient
Association Between the Safe Delivery App and Quality of Care and Perinatal Survival in Ethiopia Lund S et al. 2016 (23)	Cluster-randomized clinical trial in 5 rural districts of Ethiopia	**n = 3601** women in active labor included at admission and followed up until 7 days after delivery to record perinatal mortality	Health care workers in intervention facilities received a smartphone with a Safe Delivery App (SDA). The SDA is a training tool in emergency obstetric and neonatal care that uses visual guidance in animated videos with clinical instructions for management. The SDA conveys knowledge and skills on neonatal resuscitation. Study to estimate the effect of the safe delivery app on perinatal mortality and the neonatal resuscitation skills and knowledge of health care workers in Ethiopia. The primary outcome was perinatal death, which was de- fined as a composite of a stillbirth or an early neonatal death.	Use of the SDA was associated with a nonsignificant lower perinatal mortality of 14 per 1000 births in intervention clusters compared with 23 per 1000 births in control clusters (odds ratio, 0.76; 95% CI, 0.32-1.81). The skill scores of intervention health care workers increased significantly compared with those of controls at 6 months (mean difference, 6.04; 95% CI, 4.26-7.82) and 12 months (mean difference, 8.79; 95% CI, 7.14-10.45) from baseline, corresponding to 80% and 107%, respectively, above the control level. Knowledge scores also significantly improved in the intervention compared with the control group at 6 months (mean difference, 1.67; 95% CI, 1.02-2.32) and at 12 months (mean difference, 1.54; 95% CI, 0.98-2.09), corresponding to 39% and 38%, respectively, above the control level.	• The findings are limited by the study location and population • Blinding of intervention and control clusters was impossible owing to the nature of the intervention, which increased the risk for a selection or information bias
Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: a cluster-randomised controlled trial Lund S et al. 2012 (24)	RCT	**n = 2550** pregnant women	Twenty-four primary healthcare facilities in six districts in Zanzibar were allocated by simple randomisation to either mobile phone intervention (n = 12) or standard care (n = 12). The intervention consisted of a short messaging service (SMS) and mobile phone voucher component.	The mobile phone intervention was associated with an increase in skilled delivery attendance: 60% of the women in the intervention group versus 47% in the control group delivered with skilled attendance. The intervention produced a significant increase in skilled delivery attendance amongst urban women (odds ratio, 5.73; 95% confidence interval, 1.51-21.81), but did not reach rural women.	• The intervention not reach rural women, who are the poorest and most vulnerable to obstetric emergencies • As geographical distances, poverty, quality of care and sociocultural factors, influence the receptiveness of the mobile phone interventions

(*continued*)

TABLE 1. Characteristics of the 10 studies included in the review (population, design, study/intervention, results and limitations) (*continued*)

Study	Design	Population	Study intervention	Results	Limitations
Tele-education vs classroom training of neonatal resuscitation: a randomized trial Jain A et al. 2010 (25)	RCT	**n = 49** staff nurses	In-service staff nurses were randomized to receive training by tele-education instruction (TI n=26) or classroom teaching (CT n=22) method from two neonatology instructors using a standardized teaching module on neonatal resuscitation. Gain in knowledge and skill scores of neonatal resuscitation were measured using objective assessment methods.	Age, educational qualification and professional experience of the participants in two groups were comparable.	• Technology limitations like interruptions during the lectures inability to transmit images of the instructors and their presentation at the same time and occasional delay in the focusing of the camera
				Pre-training mean knowledge scores were higher in TI group (8.3±1.7 vs 6.6±1.4, P ¼ 0.004).	• The sample of nurses may not represent in a true sense all nurses in remote places
				Skill scores were comparable in the two groups (11.7±3 vs 10.3±2.9, P = 0.13). Training resulted in a significant and comparable gain in knowledge scores (4.2±2.2 vs 5.3±1.7; P =0.06) and skills scores (4.5±3.3 vs 5.0±3.1, P =0.62) in both the groups.	
				The post-training knowledge scores (TI: 12.5±1.7 vs CT: 12.0±1.7, P = 0.37) and the post-training skill scores (TI: 16.0±0.5 vs CT: 15.6±2.5, P = 0.55) were comparable in the two groups. Post-training scores, adjusted for baseline knowledge scores, were statistically higher in the in-person group compared with the telemedicine group (knowledge: 12.46±0.03 vs 12.16±0.01, P < 0.00; skills: 15.6±2.5 vs 16.0±2.8, P < 0.00). The quantum of lower scores in the telemedicine group was only 2% for knowledge and 6% for skills. This difference was felt to be of only marginal importance. Satisfaction scores among trainees and instructors were comparable in the two groups.	
The Effect of Nursing Quality Improvement and Mobile Health Interventions on Infant Sleep Practices Moon RY et al. 2017 (26)	RCT	**n = 1600** mothers	All participants were beneficiaries of a nursing quality improvement campaign in infant safe sleep practices (intervention) or breastfeeding (control), and then received a 60-day mobile health program, in which mothers received frequent emails or text messages containing short videos with educational content about infant safe sleep practices (intervention) or breastfeeding (control) and queries about infant care practices	1263 mothers in the adjusted analyses, receiving the safe sleep mobile health intervention had higher prevalence of placing their infants supine compared with mothers receiving the control mobile health intervention (89.1% vs 80.2%, respectively; adjusted risk difference, 8.9% [95% CI, 5.3%–11.7%]), room sharing without bed sharing (82.8% vs 70.4%; adjusted risk difference, 12.4% [95% CI, 9.3%–15.1%]), no soft bedding use (79.4% vs 67.6%; adjusted risk difference, 11.8% [95% CI, 8.1%–15.2%]), and any pacifier use (68.5% vs 59.8%; adjusted risk difference, 8.7% [95% CI, 3.9%–13.1%]).	• There was a lost to follow-up rate of 21%
				The independent effect of the nursing quality improvement intervention was not significant for all outcomes. Interactions between the 2 interventions were only significant for the supine sleep position.	• Enrollment was limited to English speakers • The large majority of responses (72.6%) occurred when infants were aged 8 to 12 weeks • This study not evaluates adverse events • This study did not measure clinical outcomes (ie, rates of sudden unexpected infant death) • This trial has limitations inherent in self-reporting

RCT, randomized controlled trials; ROP, retinopathy of prematurity; BW, body weight

and rates of large for gestational age, and no perinatal/neonatal deaths were reported. However, within the intervention group, women using the internet transmitted more data than women using the IVR system. Similarly, Seguranyes (19) et al showed that women in the intervention group made fewer visits to the health center (mean, 1 visit) than women in the control group (mean, 1.17 visits). However, the prevalence of breastfeeding at six weeks was similar in the two groups.

Jain et al (26) showed no differences between classroom or tele-education training of neonatal resuscitation. Both comparison groups showed similar improvement in knowledge and skills scores.

Studies analyzing the effect of promoting adherence to interventions in parents showed non consistent results. The two studies assessing the impact on text message reminders on immunization rates showed poor results. Niederhauser et al. (20) compared sending text messages 4 and 2 weeks prior to the due date of infant´s immunization and a similar procedure but with age-specific newborn health topics not related to immunization. Immunization compliance was similarly low in the two comparison groups. Ahlers-Schmidt et al (21) implemented a pilot study comparing the results on immunization rates and timeliness between standard notification (appointment card at the previous visit) plus reminder text messages 7 days prior to the immunization due dates and only standard notification. Non-significant differences were observed between comparison groups. Moon et al (27) analyzed the effect of two interventions (Nursing Quality Intervention and mHealth Intervention) implemented separately and combined. The intervention included health messages and educational videos delivered by email or text messages to parents. Primary outcome was adherence to four safe sleep recommendations (supine position vs other; room sharing without bed sharing vs other; any vs no use of pacifier; no soft bedding vs other). Adherence to the four recommendations was significantly higher in the intervention group.

The implementation of mHealth interventions on improving quality of care is associated with better results in the studies analyzed. Fuerch et al compared adherence to the Neonatal Resuscitation Program algorithm based on memory alone and by using a decision support tool during simulated neonatal resuscitation (22). Intervention groups showed significantly higher scores for appropriate decision to perform positive pressure ventilation and chest compression and on the frequency of FiO_2 adjustment. Lund et al (23) compared the effect of using a mobile phone app conveying knowledge and skills on newborn ventilation and use of essential drugs and equipment through animated videos versus standard care. Knowledge and skills were significantly higher in the intervention group. However, no differences were reported on perinatal mortality. Similarly, other study (24) assessed the impact of a mobile phone-based versus standard intervention on improving skilled attendance at delivery. Standard antenatal, delivery and postnatal care was compared with an mHealth intervention consisting of text messages and access to a two-way-communication between the mother and health care providers. The intervention was associated with an increase in skilled delivery attendance.

DISCUSSION

We found that telemedicine, eLearning and mHealth have been studied with the objectives of improving access, quality of care and selected outcomes in newborn health, reporting different results. Interventions targeted the health workforce and also the newborns' parents or caregivers.

Studies on telemedicine (17–19,26) analyzed its results in improving diagnosis (17) or clinical care (18,19). These studies are aligned with the main pillars that support the application of telemedicine, such as providing clinical support and connecting distant users using different kinds of technologies, and had the improvement of health outcomes as main goal. The use of telemedicine contributes substantially to the delivery of healthcare services, using ICTs for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers (28). When telemedicine was applied for diagnosis or prenatal/postnatal care, reported results support its use, improving the use of resources, facilitating access to health care and contributing to achieving results similar to those obtained when the diagnosis is made in person and with greater efficiency in terms of the use of resources.

Regarding the use of mHealth, reviewed studies did not show positive results regarding the adherence to immunization schedules, but it should be noted that one of them was a pilot study. However, positive results were observed in relation to parental adherence to safe sleep recommendations through a similar intervention (27) . In the case of the application of mHealth in the improvement of knowledge and skills by health providers, the results were adequate (22–24).

There is a high penetration of mobile technologies worldwide, reaching nearly 90% in low- and middle-income countries. This highlights the enormous potential of technology for healthcare accessibility, especially regarding immunization reminders, antenatal care and skilled birth attendance (29), even though in this review the use of immunization reminders were not successful.

It is important to consider that mHealth, as well as any other eHealth implementation, needs to be integrated as part of a comprehensive health care system (30). Reaching the target audience with a direct communication channel can help reinforce the message to be delivered and also facilitates the timely tracking and recording of vital events (31). The studies analyzed showed a limited use of mHealth in newborn health, as opposed to the possible impact of its use. Therefore, it is essential to strengthen research on this type of interventions. Since new experiences on mHealth appear constantly, partially due to the simplicity and easiness of this technology which facilitates a rapid implementation, a checklist for mHealth reporting and assessment evidence (mERA) has been developed for the proper evaluation of mHealth interventions in order to measure the appropriate results and outcomes (32,33).

Another pillar in improving the quality of neonatal care is education of the healthcare workforce and capacity building. Only one of the papers included in this review addressed eLearning in newborn health (26), and showed the relevance and adequate results of this type of strategy in training health teams. These strategies can lead to a reduction of the costs related to the provision of educational materials, facilitate the access to educational interventions and address limitations and barriers (30,34,35). It has also been shown that when compared with traditional learning, eLearning has good learning outcomes in the clinical context (36). However, again, we found that there is not enough evidence with regard to its application in newborn care.

This review has some limitations. It focused on studies published from 2008 to 2018 and had a resulting small number of papers. The quality of the papers was not measured based on standardized criteria, but assessed qualitatively. Some of the studies presented limitations that could affect the results, including small sample size, external validity, loss of follow-up of the subjects, and limited follow-up time. Although selection bias may be a concern, the risk was reduced by assigning three independent reviewers, and even when our focus was on Latin America and the Caribbean, the search was not restricted to studies from the Region.

The application of ICTs can help address challenges and tackle barriers in the provision of healthcare, and enhances access to quality services (37). It has the potential to address barriers as distance and access, but nonetheless it still shares challenges posed to healthcare in general, including poor management, insufficient training, infrastructure limitations and poor access to equipment and supplies (38).

The use of ICTs can contribute to achieving universal health coverage, improving the quality of care, promoting access and reducing inequities as well as reducing fetal and neonatal deaths (8,12,39–41).

There is evidence with variable results about the effect of ICTs and eHealth in different population groups and oriented to different health problems. However, as highlighted by this review, the availability of evidence regarding newborns is still limited (6–8,42,43).

Similarly, there is a latent chance where eHealth can help with simple interventions that could aid in diminishing inequalities by enabling simple tasks such as communication, education and data collection in any setting. Worldwide access to technology currently available can help in the collection of data and knowledge to improve the population's and the health workforce's capacity and accessibility (35).

In the context of the current pandemic by COVID-19, innovative approaches using digital platforms allow health systems to better manage the response and to maintain the delivery of essential health services and communicate to the public about how to access these services (42).

Therefore, due to the limited evidence on the use of ICTs in neonatal health and particularly in the current context, it is a priority to generate solid evidence that contributes to improving perinatal health and achieving the expected results, as well as facilitating access to care of quality health reducing the negative impact of the still existing barriers and inequalities.

Authors' contributions. All authors contributed to the study design and planning, analysis and review of the results, and writing of the initial version. PD proposed the study and coordinated the work. JS, PO, MD and SB carried out the systematic review and screening of results. LADF and SS contributed to the conceptualization and conclusions of the paper. All authors approved the final version.

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Tecnologías de la información y la comunicación en la salud neonatal

RESUMEN

Objetivos. Identificar la evidencia científica sobre el uso y los resultados de las tecnologías de la información y la comunicación para mejorar la salud neonatal en general o problemas de salud o intervenciones específicos, y describir el tipo de intervención y sus resultados.

Métodos. Se realizó una revisión sistemática de la evidencia disponible. La búsqueda se llevó a cabo en revistas revisadas por pares entre el 1 de enero de 2008 y el 30 de abril de 2018, en español e inglés. Los términos clave de la búsqueda fueron (health informatics OR telemedicine OR mHealth) AND (newborn OR newborn care OR neonatal care).

Resultados. De un total de 305 artículos identificados inicialmente, 10 artículos cumplieron los criterios de inclusión. Los principales dominios de la eSalud aplicados a la salud neonatal fueron la telemedicina (3 estudios), el aprendizaje electrónico (1 estudio) y la salud móvil (7 estudios). La población destinataria consistió en los proveedores de atención de la salud o los padres. Los estudios tenían por objeto el diagnóstico, la prestación de atención sanitaria y la capacitación, la promoción del cumplimiento de las intervenciones en los padres o la mejora de la calidad de la atención.

Conclusiones. El uso de la eSalud en general, y específicamente en la salud neonatal, muestra importantes posibilidades de desarrollo y expansión, dados los avances y las necesidades actuales, y debería considerarse un instrumento clave para la reducción de las desigualdades.

Palabras clave Tecnología de la información; salud del lactante; medicina basada en la evidencia; atención perinatal; estrategias de eSalud; telemedicina.