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Safe Provision of Oxygen to Infants in Low-Resource Settings

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SAFE PROVISION OF OXYGEN TO INFANTS IN LOW-RESOURCE SETTINGS

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Abstract

This project explored best practices for the provision of oxygen to infants in low-resource settings, culminating with the development of a script for the future production of a training video by the Global Health Media Project (GHMP). A review of the literature included practice guidelines and current research related both to the topic of oxygen delivery, and to the creation and dissemination of educational healthcare materials. Discussion with content experts helped to guide the review and script development. The script focused on young infants with evidence of respiratory distress who require supplemental oxygen, and was aimed at teaching assessment skills and demonstrating the safe delivery of oxygen. Video streamed via the Internet is uniquely suited to maximizing the reach of training materials for health care workers in low-resource settings. The video script attempted to balance best practices with the reality of health care settings in low-resource countries, where equipment and trained personnel may both be in short supply.

Keywords: Global Health Media Project, oxygen, low-resource healthcare settings, respiratory distress, video, infants, respiratory assessment

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List of Abbreviations

AHA	American Heart Association
CDC	Centers for Disease Control and Prevention
CoSTR	Consensus on Science with Treatment Recommendations
CPAP	Continuous Positive Airway Pressure
ENC	Essential Newborn Care
GHMP	Global Health Media Project
HBB	Helping Babies Breathe
ILCOR	International Liaison Committee on Resuscitation
MAF	Medical Aid Films
MDG	Millennium Development Goal
MhGAP	Mental Health Gap Action Program
NICU	Neonatal Intensive Care Unit
NONPF	National Organization of Nurse Practitioner Faculties
PaO2	Partial pressure of oxygen in the blood, measured by blood gas analysis
PEEP	Positive End Expiratory Pressure
PICO	Population, Intervention, Comparison, Outcome research question format
PPV	Positive Pressure Ventilation
RCT	Randomized Controlled Trial
ROP	Retinopathy of Prematurity
SAM	Suitability Assessment of Materials
SDG	Sustainable Development Goal
SaO2	Blood oxygen saturation measured by blood gas analysis
SpO2	Blood oxygen saturation measured by pulse oximetry
THET	Tropical Health and Education Trust
WHO	World Health Organization

Safe Provision of Oxygen to Infants in Low-Resource Settings

Global Health Media Project (GHMP) is a non-profit organization whose mission is to improve health care and health outcomes in resource-poor areas by developing videos that "bring to life" basic health care information known to save lives ("Global Health Media Project," n.d.). The organization develops and provides frontline health workers in low-resource settings with knowledge and skills via short, educational videos. Current video series include newborn care, childbirth, and breastfeeding, as well as videos on Ebola and Cholera. A video with a focus on the provision of oxygen to infants was sought as part of the newborn series of videos focusing on healthcare for infants. This project encompassed the development of the content for this educational video.

Project Purpose and Approach

The purpose of this project was the development of a video script (Appendix I), with a focus on the safe provision of oxygen to infants. The video will primarily be aimed at health care workers in low-income countries working in community and primary care settings. The goal of the script was to guide health care workers in low-resource settings to safely and appropriately care for babies requiring supplementary oxygen, building on their pre-existing skills. The primary aims of the project were:

- **Aim 1:** Develop a script for a five to seven-minute video on safe oxygen use, to be produced by GHMP for inclusion in their small baby or newborn video series.
- **Aim 2:** Increase access for health care workers in low-resource settings to the information and skills they need to provide oxygen safely to babies with respiratory distress who are seen in the community, primary care and referral settings.

To support these aims, an integrative review of the literature and clinical practice guidelines was conducted. The review assimilated and summarized current best practices for safely providing oxygen to infants in low-resource settings. Evidence, guidelines, and best practice were reviewed in light of practice settings, available resources, healthcare worker skill levels, as well as best practice in distance education. The overall approach was aimed at the creation of an accessible and useful educational resource. As Deborah Van Dyke, Family Nurse Practitioner (FNP), Founder and President of GHMP, stated: "our main task is to make sense of all the information and distill it down for health workers so it's simple and clear and safe. There is a blend of science and art and a healthy dose of practical good judgment that goes into the scripts" (Van Dyke, 2016a).

Feedback about the proposed video script was solicited from content experts, including those who are familiar with practice in low-resource settings, in order to better understand practice realities and limitations. This included consultation about oxygen and monitoring equipment most commonly available in these settings. The creation of the video script took the changing landscape of learning into account, and the impact of smart phones, tablets, and internet-based resources on environments where other, more traditional education modalities are unavailable.

Significance of Project

According to the World Health Organization (WHO), although the global rate of mortality for children under the age of five has dropped by 53% since 1990, 5.9 million children under the age of five died in 2015 ("WHO | World Health Statistics", 2016). These numbers for 2015 reflected a shortfall on the Millennium Development Goal 4 (MDG 4) of a two-thirds reduction in child mortality for ages 0-5 for the period from 1990-2015 (You et al., 2015). The

MDGs were replaced by the United Nations' Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development in 2016. These goals aim to "end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births," by 2030 (http://www.un.org/sustainabledevelopment/health/). According to the analysis by You and colleagues even if targets are met for the Sustainability Target Goal of 25 deaths for children under five to 25 per 1000 live births by 2030, some 56 million children under the age of five will die before 2030. They noted that "urgent actions are needed most in the regions and countries with high under-5 mortality rates, particularly those in sub-Saharan Africa and south Asia (You et al., 2015, p.2275)." Many countries in these regions are not currently on track to achieve this goal. The risk is highest in the WHO African region. According to the WHO "currently, 79 countries have under-five mortality rates above the SDG target of 25 under-five deaths per 1000 live births, and 24 countries have rates that are three times higher than that ("WHO | World Health Statistics 2016," 2016. p. 34). This most recent World Health Statistics report does predict that the 2030 targets may be reachable, if current momentum is sustained (p. 34).

Newborn deaths account for 45% of the mortality in children age birth to five (WHO, 2016). The majority of deaths in the newborn age group (approximately 80%) occur due to low-birth weight, and premature birth, infections, birth trauma, and lack of oxygen at birth. While various terms have been used to describe neonatal mortality due to these causes, Lawn et al. (2011) advocated for the newer term "intrapartum-related neonatal death, as a way to distinguish these deaths in newborn infants from the larger under-five age group. The WHO stated that access to skilled health care, both at home, and if necessary through referral to a hospital, could

prevent up to two thirds of newborn deaths ("WHO | Newborns," 2016). This project aimed to increase access for health care workers to the information and skills they need in order to provide oxygen to babies who need it, when available.

Defining the Video Script Focus

Clear guidance on giving oxygen to children with respiratory distress is provided in the recent WHO document *Oxygen Therapy for Children: A Manual for Healthcare Workers* (2016). This resource was helpful in the decision making process around the information most critical to convey in a video script or scripts addressing oxygen use in babies. Other key resources included guidelines on treatment of community acquired pneumonia (Bradley et al., 2011; Harris et al., 2011), and on oxygen delivery methods (Muhe & Weber, 2001; Rojas-Reyes, Granados Rugeles, & Charry-Anzola, 2014a).

Asphyxia in newborns has been recognized as a cause of morbidity and mortality as far back as 1897 (De Lee, 1897). Transient or permanent brain injury can result from hypoxic states in the newborn baby. Guidelines, including those based on the most recent Consensus on Science with Treatment Recommendations (CoSTR) statements from the International Liaison Committee on Resuscitation (ILCOR) indicate that oxygen should be used in these babies who do not quickly improve with normal stimulation, warming, and bag and mask ventilation with room air. The most recent guidelines included changes to the concentration of oxygen used for resuscitation. Other interventions, such as cooling and more advanced pharmaceutical interventions (Perlman, 2006) are usually beyond the scope of a low-resource primary care or community setting, and were not addressed in this project.

While the research indicates that room air is preferential to oxygen for initial resuscitation of most babies, oxygen use is included in a variety of resuscitation algorithms

endorsed by the ILCOR and cited in textbooks aimed at healthcare providers in the developing world (Maternal and Childhealth Advocacy International, 2015; Perlman et al., 2015; World Health Organization, 2013; Wyckoff et al., 2015a). Where oxygen use is included in resuscitation algorithms, typical recommendations for term infants include oxygen being initiated only when adequate ventilation fails to improve oxygenation levels and an appropriate increase in heart rate. Guidelines for premature infants suggest that if resuscitation is needed, it may be appropriate to initiate this with low-dose oxygen (Australian Resuscitation Council, 2011; Wyckoff et al., 2015a; Wyllie, Bruinenberg, et al., 2015; Wyllie, Perlman, et al., 2015). Wall, Lee, Niermeyer, English, Keenan and Carlo (2009) concluded that "nonavailability of oxygen is not the limiting factor for the implementation of neonatal resuscitation" (p.S53).

Given the nature of a short video, the information presented cannot be exhaustive, but must rather provide key points and instructions. Following a review of the literature and further discussions with GHMP personnel and content experts, the focus for the video script was refined to focus on the administration of oxygen to infants with respiratory distress to include neonates who have left the delivery room breathing independently, but to exclude resuscitation with oxygen in the delivery room. Content experts consulted for this project noted that oxygen is often the only available drug/implementation available at the primary care level, or even in the local referral setting; and that guidance is needed on how to safely administer oxygen to newborns, especially given that pulse oximetry equipment is not routinely available, and even if used, is unlikely to be used for continuous monitoring.

The World Health Organization, (2014) cited "safe oxygen therapy" as one element of the management of small and sick newborns (p.16), although oxygen use is not included in all resuscitation frameworks. In a 2015 webinar discussing the Helping Babies Breathe program

(Helping Babies Breathe & AAPTV, 2015), Susan Niermeyer, MD, MPH, of the University of Colorado discussed the need to frame resuscitation as a series of basic steps, rather than an intensive care intervention. Niermeyer stated that because of this re-framing effort on the part of Helping Babies Breathe (HBB), the decision was made to eliminate oxygen use in their Neonatal Action Plan, along with other more advanced skills including intubation, the delivery of medications, and chest compressions. Global Health Media Project references HBB, and according to Van Dyke would use the protocol for resuscitation if needed. The decision to focus the video on oxygen delivery outside the delivery room was further supported by Van Dyke's anecdotal observation that she has not seen oxygen used in delivery rooms in the low-resource settings in which GHMP has filmed (Van Dyke, 2016b). Any instruction in delivery-room use of oxygen, would require a separate video, as protocols and oxygen delivery methods for resuscitation differ from those used in the ongoing care of sick babies.

More advanced techniques such as the use of Continuous Positive Airway Pressure (CPAP) were also not included in the final script. As a promising and increasingly utilized technique for the care of infants with respiratory distress, the use of CPAP is briefly addressed here to provide context. Currently, CPAP use is outside the scope of many low-resource settings, however basic CPAP may be a promising focus for a future video.

Relationship to advanced nursing practice

The National Organization of Nurse Practitioner Faculties (NONPF) has outlined the Nurse Practitioner Core Competencies – the "essential behaviors" and dispositions that all nurse practitioners should exhibit as they practice to the full scope of the nurse practitioner license (NONPF, 2012). These competencies include the use of "analytic skills for evaluating and providing evidence-based, patient centered care across settings; and advanced knowledge of the

health care delivery system (p. 1).” Illustrative of the Scientific Foundation Competencies, this video script development project required an analysis and evaluation of current guidelines and best practices, integrated within the context of low-resource settings; as well as an understanding of differences in health-care delivery systems across settings. It was designed to translate research and other forms of knowledge into teaching points that could improve practice processes and outcomes in low-resource populations. Education for health care workers in diverse practice and cultural settings was a key component. Educational videos that will be viewed in multiple contexts and in a variety of cultural settings must succeed in capturing and communicating the essence of evidenced-based patient care in a way that is as universally accessible as possible.

Leadership Competencies addressed by this project included providing “leadership to foster collaboration with multiple stakeholders (e.g. patients, community, integrated health care teams, and policy makers) to improve health care” (NONPF, 2012, p. 2). The project clearly advocated for improved access and quality of health care. Within the area of leadership, NONPF identifies effective oral and written communication as key skills. The use of video in this project can be considered a natural extension of this competency, encompassing the concept of visual and media literacy. The nurse practitioner must consider how culture and mode of communication influence the message to be communicated. Relevant Quality Competencies include the anticipation of “variations in practice” (p.2), essential for a project aimed at diverse populations and arenas, while still utilizing and communicating the best current evidence with the goal of improving outcomes for patients, growing the skills of community health care workers, and empowering families. This is further supported by the Practice Enquiry

Competency, which requires nurse practitioners to "disseminate evidence from inquiry to diverse audiences using multiple modalities" (p.3).

Additional NONPF competencies that impacted this project include Policy Competencies, which speak to consideration of constraints or opportunities inherent in funding opportunities or limitations, and policy development around global healthcare interventions and national public health initiatives. These may range from the creation of donation policies by organizations in the developed world, to the impact of globalization on partnerships and policy development" (NONPF, 2012).

A survey of nursing faculty in the Americas (Wilson et al., 2012), looked at perceptions of global health competencies for undergraduate nursing students. In addition to an understanding of the globalization of health care, the competencies included broad categories: the global burden of disease; the health implications of migration, travel, and displacement; social and environmental determinants of health; health care in low-resource settings; and health as a human right. Specific competencies related to health care in low-resource settings speak to the ability of the nurse to identify the clinical strategies that are most likely to positively affect individual or population health within these settings, and the ability of the nurse to be adaptable to the setting and available resources – adapting their practice to fit the context in which they find themselves (Wilson et al., 2012). As advanced practice nurses participate in policy and leadership activities, they need to adapt best practices to fit within resource and other constraints, and to ensure that program funds and other resources are used wisely. For this project it was necessary to consider what equipment was most likely to be present in a low-resource setting, in an attempt to create an instructional video script that would have the greatest impact on the maximum number of patients and be accessible to as many healthcare workers as possible.

The Faculty Competencies for Global Health (Etzel et al., 2014) were developed by the Academic Pediatric Association Global Health Task Force, and endorsed in 2015 by the American Academy of Pediatrics. The authors identified five competency domains: Values/Ethics, Roles/Responsibilities, Communication, Team Building and Teamwork, and Special Considerations – including the implications of working in unfamiliar cultural contexts or those where resources are limited. The Global Health Task Force was convened with the aim of collaboration between "diverse pediatric academic societies and groups to advance global child health" (p.1). Selected competencies are termed "universal" and intended to be "relevant to all those working in global health, whether in research, education, administration or clinical practice " (p. 2). In addition to practice competencies, education competencies were outlined. While these were written to guide faculties in working with students of global health, they also translate appropriately to the development of educational resources for use globally. Specifically the Values, Communication, and Teamwork competencies speak to the adaptation of educational programming to the intended audience, including "bidirectional educational opportunities with global partners" when feasible, and consideration of the "needs, resources, cultural paradigms, and educational levels of the target audience to shape the content and venue for educational programs (p.5).

Anticipated Benefits and Contributions of Project

The anticipated benefits of this project were to:

1. Enhance the available video educational resources for healthcare workers in low-resource settings.
2. Increase knowledge among healthcare workers in low-resource settings regarding the safe use of oxygen to treat infants with respiratory distress.

3. Increase the potential for survival in infants who require oxygen due to respiratory distress, as a result of increased healthcare worker knowledge.
4. Reduce potential harm from inappropriate use of oxygen and hyperoxia, including retinopathy of prematurity (ROP) and bronchopulmonary dysplasia through increased healthcare worker knowledge.

The WHO (2016) noted that oxygen "remains an inaccessible luxury for a large proportion of severely ill children" (p.1). The WHO also stated that increasing the knowledge of health workers on the clinical signs of hypoxemia, more widespread use of pulse oximetry, and the use of oxygen concentrators running on traditional or alternative power, could have significant impact on health.

Oxygen is frequently viewed as a somewhat benign intervention. Yet the implications for using oxygen inappropriately can be profound in neonates, who can experience a rapid shift from the relatively hypoxic intrauterine environment to a potential hyperoxic state induced by the administration of supplementary oxygen. Educating health care providers about the risks of over oxygenation is aimed at increasing survival, while decreasing the risk of ROP, chronic lung disease, and brain injury.

Retinopathy of prematurity is primarily seen in premature infants, and can lead to blindness. The incidence decreases as gestational age and birth weight increases. ROP occurs when the normal vascularization of the retina is compromised, and the interruption of normal growth is followed by abnormal vessel growth. ROP can be reduced or prevented by carefully controlling the partial pressure of oxygen (PaO2) or blood oxygen saturation (SaO2 or SpO2) levels in babies receiving supplementary oxygen. A Cochrane review that looked at five clinical trials suggested that reduced oxygen could positively impact ROP outcomes without increasing

mortality, although the data for mortality rates were not complete for all five trails reviewed. The review's authors concluded that "(the now historical) policy of unrestricted, unmonitored oxygen therapy has potential harms without clear benefits (Askie, Henderson-Smart, & Ko, 2009, p.7)."

High oxygen concentrations, especially when combined with positive pressure ventilation, can result in lung over-inflation and the triggering of a systemic inflammatory reaction. The result can be chronic lung disease and bronchopulmonary dysplasia (Vento & Saugstad, 2009). In addition, the development of an antioxidant defense mechanism does not happen until relatively late in gestation, meaning that premature babies are at particular risk for the damage produced by hyperoxia, and early oxidative stress can result in the eventual development of bronchopulmonary dysplasia (Vento & Saugstad, 2009). The potential harms of hyperoxia to newborn lungs has been recognized in CoSTR statements going back to 2000 (Wyllie, Perlman, et al., 2015). Saugstad (2005) noted that "minimizing exposure to high concentrations of oxygen reduces the risk of …complications. The neonatologist would be well served to think of oxygen as a medication and use it sparingly. Oxygen appears to be more toxic than previously believed" (p. S48). The risks of hyperoxia may be highest when oxygen is administered using positive pressure ventilation in the delivery room, especially for premature infants, however accurate measurement of oxygen saturation in any infant receiving oxygen is an important element of therapy, and therefore of this video script.

Benefits of Video as an Educational Tool in Low-Resource Settings. The proliferation of mobile technology such as smart phones and tablets, combined with social media, has dramatically altered the global learning environment. Providing education on best clinical practices via video is now a feasible and cost-effective modality to reach large numbers of healthcare workers in low-resource settings. As Pimmer et al. (2014) concluded, mobile devices

and social media tools are "suitable to connect learners and learning distributed in marginalized areas" (p.1).

This project brought together existing guidelines and best practices in a short video script. The resulting video, when complete, will have the potential to be viewed multiple times, downloaded and shared, and used by individual community healthcare providers and organizations or by groups seeking educational resources. Video that uses real patients and health care providers, and is set in a low-resource setting allows the audience to see best practice in a context that they may be better able to relate to their own practice environment.

The digital library in GHMP's archive allows viewers to access content when and where they wish, and to download it to personal smart devices for viewing as needed when Internet access is not available, or for sharing with peers. The use of video is a cost effective way to reach a large audience, as evidenced by GHMP's current estimated reach of 7.7 million views to date (over approximately four years), and Medical Aid Films' (MAF) reach of 2 million views per year as reported on their respective websites ("Global Health Media Project," n.d., "How we make a difference," n.d.). In addition, using video to build on the skills and resources available in the field can provide significant impact, while avoiding the potential challenges and pitfalls of donating equipment that may or may not be beneficial, or providing in-the-field training that may be limited by availability of trainers and healthcare workers, time, and travel requirements. The cost benefit ratio of video is potentially large, and video can also complement other interventions and education. Online resources are also more easily updated to reflect current recommendation, changes in practice, and new information as it becomes available.

Nursing and Learning Theory: Leininger's Culture Care Theory and Mayer's Cognitive Theory of Multimedia Learning

In devising a video script, this student author had to consider the essential health care interventions and practices to be communicated, their cultural context, and how best to create a meaningful pairing of words and images in order to create an optimal learning tool. Both nursing and learning theory influenced this process.

Leininger's Culture Care Nursing Theory (2002) puts the focus on caregivers, patients, and healthcare institutions within what Leininger terms the "diverse health context." She stated that "the *purpose* and *goal* of the theory is to use research findings to provide culturally congruent, safe, and meaningful care to clients of diverse or similar cultures" (p.190). This theory addresses the global nature of nursing, with continued relevance as nursing and the provision of health care in general become ever more global. Leininger's Sunrise model, arising from her theory, acknowledged that health care decisions are made in a local context with surrounding broader influences, and that such decisions need to account for transcultural differences. She stated "culture care concepts, meanings, expressions, patterns, processes, and structural forms vary transculturally, with diversities (differences) and some universalities (commonalities)" (p.191).

Like Leininger's work, this project was based both on acknowledging differences - including resources, education, and access to referral care - and in seeking out universalities - including modes of communication that would speak to health care providers in diverse communities around the world. Video, in a variety of delivery mechanisms, is an increasingly ubiquitous learning modality, whether formally or informally, and arguably the most accessible method of delivering information widely. The use of on-site film locations reflecting low-

resource settings, attempts to come as close as possible to a shared baseline for health care workers who are practicing in these settings.

Drevdahl, Canales, and Dorcy (2008) proposed that we need to move beyond cultural competency as advocated by Leininger and directly address the social determinants of health. They claimed, "although cultural competence may be an important aspect of clinical care, a focus on culture does not address health risks" (p.25). Any concern for cultural relevance needs to be balanced with evidence-based practice, and compromises in care provided should be avoided, or undertaken with full knowledge if this is not possible. However, addressing health risks and acting with cultural competency cannot be seen as mutually exclusive activities. Attempting to apply clinical guidelines developed with high-resource settings as a benchmark will not benefit the intended recipients of care, unless the realities of low-resource settings and practice environments are acknowledged and planned for in terms of interventions. Drevdahl, Canales, and Dorcy proposed that “rather than continuing to rely on cultural competence, we need to engage in critical thinking, reflective practice, and political action if we are to end existing health disparities and create a more socially just healthcare environment and society for all” (p. 25). Certainly, the health disparities in low-resource settings cannot be ameliorated in any meaningful way through culturally competent nursing actions without significant fundamental changes on a global level. Yet this does not negate the potential for tools such as GHMP’s videos to have a meaningful impact. In order to do so, they must be produced in ways that are culturally relevant.

Mayer (2010) proposed that "multimedia learning - learning from words and pictures is particularly relevant to medical education" (p.543). His Cognitive Theory of Multimedia Learning asserted that learners acquire new material separately, depending on whether it is

verbal or pictorial, and that "meaningful learning occurs when learners engage in appropriate cognitive processing during learning, including attending to relevant material, mentally organizing it into a coherent cognitive representation, and integrating it with prior knowledge activated from long-term memory" (p.544). Mayer's (2014) "multimedia principle" proposed that learners do better with words and images combined, rather than with words without images. Images are not automatically superior to words however; "simply adding pictures to words does not guarantee an improvement in learning" if the message is not created in a way that is "sensitive to what we know about how people process information" (pp.44-45). He stated that it is the integration of words and visual information that is key to multimedia learning. It is a complex process on the part of the learner, which can be optimized through careful application of the principles in his theory.

Mayer included design principles for what he terms "multimedia lessons" a description that could appropriately be applied to GHMP's videos. These principles include: a focus on essential material, and elimination of material that is not pertinent; pre-training for the learner for any definitions; breaking learning into smaller segments that can ideally be controlled by the learner; using spoken rather than written words; use of a human voice rather than an automatically generated one; and the presentation of material in a conversational voice. Mayer divided memory into sensory, working, and long-term components. He argued that learning can be limited by the capacity of working memory, and that "material must be condensed and organized into meaningful chunks" if learning is to occur here. Furthermore he asserted that the "central work of multimedia learning takes place in working memory" (2014, p.53). The script produced for this project comprises the words; the final video will contain visual elements are suggested, to facilitate this multimedia learning.

Definitions

Low-Resource Setting. For the purposes of this project, the term "low-resource setting" was not strictly defined. In general, it was used to refer to a medical setting where resources (treatment options, health care staff, hospital beds, technical equipment etc.) are typically in short supply. These settings are almost always found in low or low-middle income countries.

Low and middle-income countries are defined by the World Bank, based on an estimate of gross national income, with the terms "economy" and "country" used interchangeably for this purpose. The data is updated on an annual basis. According to the World Bank's Data website, for fiscal year 2017, low-income economies had a 2015 per capita gross national income of $1,025 or less. Lower middle-income economies had a per capita gross national income of $1,026 - $4,035. Upper middle-income economies were those with a per capita gross national income of $4,036 - $12,475. These income levels are in US dollars, converted from local currency, and based on population estimates from several sources (The World Bank, 2015).

In an article for the Centers for Disease Control and Prevention's Morbidity and Mortality Weekly Report, St. Louis (2012), discussed differences in health surveillance in low and high resource countries. He proposed three distinguishing elements of health surveillance in low-resource countries: "1) more must be done with less, 2) strengthening surveillance is more complicated, and 3) sustainability is more challenging" (p.15). This can be usefully extrapolated to health care generally in low-resource settings - where more must be done with less, strengthening the care provided and related infrastructure can be more complicated, and sustainability is more challenging. Videos produced by GHMP are aimed at providing educational tools to providers, and by extension patients, in low-resource countries around the world, and the content is tailored to settings where better access to health care is needed.

Prematurity. It was difficult to find a clear definition of prematurity, and various documents and guidelines cited in this project used differing age limits. The 2015 Resuscitation Guidelines from ILCOR (Wyllie, Perlman, et al., 2015) cited varying gestational age cut-offs throughout the document, depending on which protocol was discussed. With regard to initiation of oxygen use when resuscitating newborns, they used 35 weeks of gestational age as the line between using room air (35 weeks or older) and a low-concentration of oxygen (less than 35 weeks). The WHO Every Newborn Action Plan (2014) used 37 weeks as a cut-off, while the WHO Safe Childbirth Checklist (2015) recommended special care for all newborns born more than one month early or weighing less than 2500 grams. This weight cut-off may be more useful in the low-resource setting, where accurately determining gestational age or due dates may be difficult. Ultimately the determination of whether a baby initially qualifies as preterm or low birth weight may rely on birth attendant judgment. Since resuscitation efforts happen almost immediately after birth there may be no time to weigh a baby before providing resuscitation breaths, or oxygen.

A Note on Language

The videos developed by the GHMP are narrated with a voice-over rather than with direct conversation or speech by those depicted. This eliminates the need for dubbing, since translations in other languages can be overlaid on the visual material directly. Currently, GHMP offers videos in English, Spanish, French, Swahili, Nepali, Lao, Khmer, Kinyarwanda, and Vietnamese. In addition to these official translated versions, other organizations have created audio in additional languages for use in specific settings. In order to enable easy translation, the video itself needs to be as universal as possible, while recognizing that no one cultural context can speak to all. The *Making Health Communication Programs Work* guide (1989, updated)

advocated segmenting target audiences for health education materials by behavioral, cultural, demographic, physical, and psychographic differences (p. 24-25). This segmentation was not feasible for the type of resource and distribution proposed by this project however. Further discussion of language and accessibility is contained in chapter three.

Chapter II

Review of the Literature

The evidence in the literature, including best practices for the provision of oxygen to infants who exhibit respiratory distress, and for neonatal resuscitation and oxygen use, was surveyed within the context of low-resource settings. Particular attention was paid to the WHO 2016 manual on oxygen use ("WHO | Oxygen therapy for children," 2016). This review focused on newborn and premature infants in low-resource settings, and considered oxygen use and monitoring. The most recent ILCOR Consensus Guidelines (Wyllie, Perlman, et al., 2015) were also reviewed in detail. The complications that can result from inappropriate or excessive use of oxygen, as well the barriers that can exist within low-resource settings were discussed. The utility of a stepwise approach to care, based on available resources was considered in light of this discussion. Additionally, this review examined the use of video as a teaching and communication tool, and literature relevant to producing a video aimed at a wide audience in culturally diverse settings.

Guidelines on Oxygen Use and Neonatal Resuscitation

Determining which babies should be resuscitated and what clinical algorithms should be applied in any given setting can be challenging, since much may depend on what resources (both human and technological) are locally available. Guidelines for neonatal resuscitation have in large part focused on high-income countries. At the same time, low income countries and low-resource settings shoulder a disproportionate burden in terms of neonatal mortality (Lawn, Kerber, Enweronu-Laryea, & Massee Bateman, 2009). In addition, equipment and supplies are often not only in short supply, but ill-suited to use in the field in less than optimal conditions (Maynard et al., 2015). Recommendations for neonatal resuscitation are summarized here, with

the recognition that the provision of oxygen in the delivery room differs significantly from its provision outside the setting of resuscitation. The video script for this project is designed to focus on the latter.

Initiating resuscitation. According to Wall et al. (2009), there was "a need for a systematic clinical definition of the baby who needs resuscitation and a simplified, but acceptably specific, case definition for resuscitation at the community level (p.S49)." The WHO Guidelines on Basic Neonatal Resuscitation (2012) provided guidance, as did algorithms from *Helping Babies Breathe*, and the American Heart Association / American Academy of Pediatrics (Wyckoff et al., 2015a) among others. The WHO Guidelines acknowledge that there is a still a reliance on expert consensus, rather than evidence based practice.

The WHO Guidelines on Basic Newborn Resuscitation (2012) discuss when and how to start newborn resuscitation in babies who do not respond to initial stimulation and drying. The guidelines recommend that provision of adequate ventilation should be prioritized over chest compressions (p. 8). Recommendation 8 in the guidelines states "in newly-born term or pre-term (<32 weeks gestation) babies requiring positive-pressure ventilation, ventilation should be initiated with air" (p.33). Remarks on this recommendation clarified that preterm babies should be started on 30% oxygen; if this is not possible, room air is preferable to 100% oxygen (p.33). The discussion also noted that while pulse oximetry is useful and desirable, it is not always either available, or easy to implement" (p.33). The Guidelines also state that the evidence for which interface or device (face mask, nasal canulae etc.) should be used for providing resuscitation is limited.

The 2015 American Heart Association (AHA) Neonatal Resuscitation Guidelines (Wyckoff et al., 2015a) state that positive pressure ventilation (PPV) should be initiated if the

infant is not breathing or the heart rate is less than 100/min after the initial resuscitation steps are completed. The AHA recommends the use of pulse oximetry when resuscitation "can be anticipated, when PPV is administered, when central cyanosis persists beyond the first 5 to 10 minutes of life, or when supplementary oxygen is administered" (p. S547). In newborns of less than 35 weeks gestation the AHA recommends starting oxygen at 21%-30%, and then titrating with the goal of achieving pre-ductal oxygen saturation levels comparable to those seen in healthy term infants.

ILCOR Consensus Guidelines. The most recent CoSTR recommendations from ILCOR (Wyllie, Perlman, et al., 2015) guided the American Heart Association Neonatal Resuscitation Guidelines and the European Resuscitation Council Guidelines among others (Wyckoff et al., 2015a; Wyllie, Bruinenberg, et al., 2015).

The CoSTR committee recommended against initiating resuscitation for preterm infants (those less than 35 weeks gestation) using high oxygen concentrations (65%-100%). They recommended initiating resuscitation with low oxygen concentrations (21%, or room air -30%) for preterm infants. This was deemed a strong recommendation with moderate-quality evidence. Lead author, Wyckoff stated that "the 2005 guideline recommended starting at a high oxygen concentration of 100%, and in 2010 that was changed to a suggestion to start with room air or blended oxygen and to titrate the oxygen concentration to meet goal saturations. For the 2015 guidelines, there were more studies available that suggested that initiation of resuscitation with low concentration of room air to 30% limits the risk of oxygen toxicity compared to higher starting concentrations" (Krader, 2015, p.3) Earlier research by Wall et al. (2009) also discussed the research on the use of oxygen versus room air for neonatal resuscitation, and concluded that room air is preferable for most babies, resulting in lower mortality. Wall et al. (2009) also noted

that those babies who have experienced hypoxia in the intrapartum period may experience periods of apnea and may require supplemental oxygen "especially if there is hypoxic lung injury or meconium aspiration (p.S55)."

The CoSTR committee did not find any human data to assess the concentration of oxygen that should be given when a newborn requires CPR. They also did not find any animal evidence to support using higher concentrations of oxygen during CPR. Despite this, they stated that "it would seem prudent to try increasing the supplementary oxygen concentration" for babies who have reached the point of requiring CPR including chest compressions (Wyllie, Perlman, et al., 2015 p.e185). If a higher level of oxygen is used, this should be weaned as soon as possible once the heart recovers. The committee admitted that there is no concrete evidence to back this particular guidance, and further stated they could be seen to be "making a conscious decision to take no notice of the evidence" (p.e186). More research will be required to conclusively decide this question; for now, it remains in the guidelines, while leaving exact levels to provider discretion. For example, the European Resuscitation Council Guidelines (Wyllie, Bruinenberg, et al., 2015) stated "ventilatory support of term infants should start with room air. For preterm infants, either air or a low concentration of oxygen (up to 30%) should be used initially. If, despite effective ventilation, oxygenation (ideally guided by oximetry) remains unacceptable, use of a higher concentration of oxygen should be considered" (p.249).

Oxygen Use in Children with Respiratory Distress

Oxygen use is not limited to delivery room resuscitation, but is also used in those infants who develop signs of respiratory distress, or who require ongoing support following resuscitation. This project's video script was aimed at this cohort. Low-dose supplementary oxygen is preferred in the delivery room only for those infants who are premature during initial

resuscitation efforts. Oxygen may also be indicated for all infants who develop signs of respiratory distress, or who are unable to sustain an oxygen saturation of greater than 90% after the first hours of life. The WHO manual *Oxygen Therapy for Children* (2016) advocates that oxygen be given to any child who exhibits any of the following: "SpO2 of less than 90%, central cyanosis, nasal flaring, inability to drink or feed (when due to respiratory distress), grunting with each breath, depressed mental state" (p.15). The manual also identifies some additional signs of hypoxemia: "fast breathing (respiratory rate of 70/min or more), severe lower chest wall indrawing and head nodding" (p.9 & p.15). These additional signs are not absolute, and the WHO notes that they should be used in the context of the "overall clinical condition" of the child. Pulse oximetry is recommended as the best way to assess for hypoxemia, and may "reduce unnecessary oxygen administration, thus ensuring the most efficient use of an expensive resource" (p.14).

Guidelines issued by the British Thoracic Society (Harris et al., 2011) and the US Pediatric Infectious Diseases Society and the Infectious Diseases Society of America (Bradley et al., 2011), dictate the management of community-acquired pneumonia in infants and children, including oxygen use. Both Harris and Bradley included severity assessment criteria, which can be used to help determine which children should receive hospital care, including oxygen. Harris and colleagues listed clinical signs (temperature, respiratory rate, moderate to severe chest retractions, nasal flaring, cyanosis, intermittent apnea, grunting, lack of feeding, tachycardia, capillary refill time) as evidence of severe disease. The authors clarified that "there is no single validated severity scoring system to guide the decision on when to refer for hospital care" (p.213). It may be influenced by other risk factors, ability of parents to manage the child's illness, and possibly parental anxiety level. Two recommendations for referral to hospital include

oxygen saturation of <92% (grade B+) and "absent breath sounds with a dull percussion note on auscultation" (grade B-) (p. ii14). Bradley and colleagues divided severity criteria into “major” and “minor,” with major criteria including “mechanical ventilation, fluid-refractory shock, acute need for non-invasive positive pressure ventilation, and hypoxemia requiring FiO2 greater than inspired concentration or flow feasible in general care area” (p.621). They recommended hospitalization when: oxygen saturation is <90%; an infant is less than 3-6 months old; the suspected or confirmed cause of a pneumonia is a virulent pathogen; or when it may not be possible to adequately care for a child at home. This discussion extended to criteria for admittance to the intensive care unit, not included in the scope of this project.

Assessing Oxygen Levels. Pulse oximetry was identified as an optimal method for assessing an infant with possible respiratory distress. The WHO manual (2016)provided a strong recommendation for the use of pulse oximetry as a first line method for detecting hypoxemia whenever possible (p.10). The manual noted that no studies comparing arterial blood gas levels with pulse oximetry have been completed in children, and concluded that "blood gas analysis is not suitable for most hospitals with limited resources" (p.20), due to high cost of the analyzers and the reagents used.

A review by Ayieko and English (2006) noted that "observers also often disagree over whether” a clinical sign is “present or not and the usefulness of the sign may vary with the age of the child" Equipment is not always on hand or reliable, however, and "it is important that health workers can identify very sick patients clinically and can identify the clinical signs of hypoxemia, rather than relying on monitoring equipment that is not available or functions poorly" (p.10).

A 2014 Cochrane Review (Rojas-Reyes, Granados Rugeles, & Charry-Anzola, 2014) concluded that "there is no single clinical sign or symptom that accurately identifies hypoxemia" (p.2). The review included 13 studies of clinical criteria in children with lower respiratory tract infections. A meta-analysis of the study data was not performed, due to heterogeneity of the clinical factors across the various studies. The review concluded, that of all clinical signs of hypoxemia included, only nasal flaring was found to be a consistent indicator in all the included studies. In addition, the review's authors cautioned against an over-reliance on chest in-drawing as an indicator for oxygen need, unless assessed in conjunction with other clinical signs, due to "widely variable" sensitivity and specificity of this sign across the included studies and age groups. The review by Ayieko and English (2006), concurred with the utility and importance of clinical signs in settings where pulse oximetry is not available. The authors recommended the use of a combination of clinical signs, (including "respiratory rate >60, inability to feed, altered mental status") since sensitivity for most signs is sub-optimal. (p.310)

The WHO (2016) concluded that there is a strong argument to be made both for the “use of pulse oximetry in the management of sick neonates” and for the “importance of teaching health workers to screen for …common clinical signs" (p.11). The challenge remains that "even the best combinations of clinical signs commonly lead to misdiagnosis of hypoxemia in some patients with normal oxygen saturation or fail to detect some hypoxemic patients" (p.14).

Delivery Methods for Oxygen in Children with Respiratory Distress. Delivery methods for oxygen include nasal prongs or cannula, nasopharyngeal catheter, head box, or facemask. Nasal prongs are recommended by the WHO (2016) as most appropriate for delivering oxygen in low-resource settings, where humidification and/or nasogastric tubes may not be available, since both humidity and nasogastric tubes are recommended with the use of nasal and

nasopharyngeal catheters. At low flow rates (0.5-1L per minute), humidification is not required, and the risk of stomach distention caused by oxygen is low, meaning that it is not necessary to use a nasogastric tube simultaneously. The manual notes that nasal catheters and nasopharyngeal catheters are also acceptable delivery methods (with nasopharyngeal catheters providing the best oxygenation). A nasogastric tube is needed with both these methods, and humidity is also required when using a nasopharyngeal catheter.

Nasal prongs or cannula are prongs attached to tubing fitted inside the nostrils, but do not extend up into the nasal cavity more than 1-2mm. A nasal catheter is a tube that extends further up the nostril, ending in the nasal cavity. A nasophayngeal catheter reaches even further into the nasal cavity - terminating just inside the pharynx, and has several small holes in the distal end of the catheter tubing. A face mask fits over the face of the infant and is connected to an oxygen source. Holes in the sides of the mask allow room air in and exhaled air out. A head box or hood is placed over and around the infant's head. Both nasal and nasopharyngeal catheters have a risk of drying if supplemental humidity is not used, and can also cause gastric distention, if oxygen gets into the baby's stomach. Head boxes and face masks may require high flow rates in order to avoid carbon dioxide build up.

A 2001 review by Muhe and Weber (Muhe & Weber, 2001) examined oxygen delivery methods that are congruent with small hospitals in low-resource countries, looking at factors including cost, oxygen concentration, comfort for the patient, need for humidification, monitoring required by nursing staff and overall safety. The authors stated that, while nasal prongs, nasal catheters, and nasopharyngeal catheters are all effective in delivery adequate oxygenation for children with pneumonia or bronchiolitis, nasal prongs should be the "method of choice for oxygen delivery in small hospitals in developing countries" (p.1). The authors cited

the need for "close supervision" when using nasal catheters or nasopharyngeal catheters. Catheters tend to be readily available in small hospitals, because nasogastric or pediatric suction tubes can be easily adapted for this use, and are cheaper than nasal prongs. The authors cited a cost (at the time of their writing in 2001) of approximately $0.10 US for a catheter, versus $2-5 US for a set of prongs. Nasal catheters were recommended by this review as a second choice, when nasal prongs are not available, with nasopharyngeal catheters reserved for situations when: nursing supervision is adequate; nasal prongs/nasal catheter do not achieve adequate oxygenation; or the oxygen supply is very limited since they are more efficient in their use of this resource. The authors also briefly discussed the use of oropharyngeal catheters - a catheter inserted into the pharynx rather than through the nose. The authors concluded that further studies were needed examining their use.

The 2014 Cochrane Review update on oxygen therapy in children (Rojas-Reyes et al., 2014) aimed to "determine the effectiveness and safety of oxygen therapy and oxygen delivery methods in the treatment of lower respiratory tract infections and to define the indications for oxygen therapy in children with lower respiratory tract infections" (p.1). The population was children aged three months to 15 years with severe lower respiratory tract infections. There were four studies reviewed for the update looking at "non-invasive delivery methods" of oxygen including 479 participants who received oxygen in hospital wards and emergency rooms. "Three RCTs (399 participants) compared the effectiveness of nasal prongs or nasal cannula with nasopharyngeal catheter; one non-randomized controlled trial (80 participants) compared head box, facemask, nasopharyngeal catheter and nasal cannula" (p.2) where the nasopharyngeal catheter acted as the control method. The review examined whether oxygen interventions avoided treatment failure - defined as lack of "adequate arterial oxygen saturation" (p.2)

measured either by SaO2 or SpO2, as well as improvement in clinical respiratory signs and oxygen saturation. The review also addressed adverse effects of oxygen administration, including "nose ulceration or bleeding, nasal obstruction, discomfort in the first 24 hours, need for mechanical ventilation, and death during treatment" (p.12). The effectiveness of delivery methods, and the flow rates needed to achieve satisfactory oxygen saturation were identified as secondary outcomes. In addition, 14 studies were included that considered the clinical indicators of hypoxemia. This review did not include CPAP; the authors stated that they felt CPAP would merit further evaluation in a separate review. Limitations of the review included the relatively small number of trials that investigated oxygen therapy and delivery as treatment for lower respiratory tract infections. Study biases were identified based on the lack of blinding and allocation methods for treatment that were not randomized. The review conclusions stated that there was "insufficient evidence to determine which non-invasive delivery methods should be used in children with lower respiratory tract infections and low levels of oxygen in their blood" (p.2.) although the quality of the evidence was considered to be low. Nasopharyngeal catheters and nasal prongs were found to be "similar in effectiveness." Nasopharyngeal catheters were associated with more problems related to mucus blockage than nasal prongs - the quality of this evidence was also low. Nasal prongs did not prevent children with severe pneumonia from developing hypoxemia. Although face masks and head boxes were included in the review, the authors felt they have not been studied well enough. In considering nine clinical signs for assessing hypoxemia, the review concluded “there is no single clinical sign or symptom that accurately identified hypoxemia" (p.2).

Harris et al. (2011) discussed the use of nasal cannula, headbox, and face mask as delivery systems. They did not prefer one delivery method over another, although they noted that

nasal cannula make feedings easier. The focus of these particular guidelines was on treatment of community-acquired pneumonia in the United Kingdom, where hospital care is widely available. The authors did caution against the use of nasogastric tubes, especially for small infants, on the grounds that these may "compromise respiratory status" (p. ii15).

David Woods, MD (2016), stated that "giving oxygen by simple nasal prongs supplies a little CPAP and this is the best way of providing oxygen to small babies at a primary care level". Although, nasal prongs are preferred, nasal catheters have the advantage of being significantly cheaper, and can also be improvised from readily available nasogastric tubing (Muhe & Weber, 2001).

Complications Resulting from Oxygen Use

The consequences of over oxygenation in premature infants are well documented, and include retinopathy of prematurity (ROP), chronic lung disease, and brain injury. Deuber and Terhaar (2011) noted that exposure to high levels of oxygen, even for brief durations, can be especially toxic to "premature infants who lack adequate protection from indigenous antioxidants. Even a few minutes of hyperoxia may increase oxidative stress cascade activity for weeks in this fragile infant cohort" (p.268). Furthermore the authors noted that the fetal environment before birth is "relatively hypoxic," an environment for which babies are well suited. This is an important consideration for pre-term infants since "adaptive response mechanisms suited to higher oxygen saturation states are immature and ineffective in neonates. Preterm birth results in the abrupt and premature exposure to comparatively high levels of oxygen absent mechanisms required for effective response" (p.269).

Interestingly, Chen, Guo, Smith, Dammann and Dammann (2010) found that low O2 saturations during the first weeks of life for infants born at less than or equal to 32 weeks of

gestational age as *well as* higher oxygen saturations given after 32 weeks of gestational age were *both* associated with a decrease in the risk of severe ROP. The authors reviewed ten studies with the following inclusion criteria: oxygen-saturation level measured by pulse oximetry; cohort study or RCT design; raw (grouped) data to calculate estimate; gestational age of ≤32 weeks at birth; and timing of oxygen saturation for ROP supplied to distinguish 2 different phases for ROP. The authors noted that these results can be explained by the two phases of ROP pathogenesis: the vaso-obliterative phase, characterized by the slowing or elimination of new vessel growth, triggered by hyperoxia, and the proliferative phase, in which high levels of vascular endothelial growth factor are triggered by relative hypoxia, resulting in increased vessel growth. They concluded that timing and oxygen-saturation level are both important, and that "low oxygen saturation in the first phase combined with high oxygen in the second phase of ROP pathogenesis might achieve greater protection than low oxygen alone (Chen ML et al., 2010, p.e1490,)."

For the purposes of this video, all oxygen use was presumed to happen outside the delivery room, and did not include resuscitation. While oxygen levels for premature and low birth weight infants are important, the delivery of supplemental oxygen through nasal prongs or a nasal catheter (rather than through a mask during resuscitation) does not require blended oxygen, but can be given using 100% oxygen.

Barriers to Oxygen Use in Low-Resource Settings

The barriers to scaling up oxygen use, including newborn resuscitation efforts, in low-resource settings include lack of training for health care workers, and lack of appropriate equipment. Maynard et al. (2015) compared the "gold standards of care" for premature infants in high resource settings with the realities of attempting to provide care in settings where resources

are limited. They proposed, "most neonatal health-care technologies…are designed for high-income countries and are either unavailable or unsuitable in low-resource settings, preventing many neonates from receiving the gold standard of care" (p.1). They concluded that there is "an urgent need for neonatal health-care technologies which are low-cost, robust, simple to use and maintain, affordable and able to operate from various power supplies" (p.1). A systemic review by Thairu, Wirth and Lunze (2013) further noted that "in current practice, most health technologies in the developing world are still donated, often ignoring local needs and rarely being used beyond the initial year" (p.119). Regulating levels of oxygen for pre-term infants in low-resource settings, as suggested by Chen et al. (2010) is likely to be challenging, especially where pulse oximetry machines are shared between multiple infants, or are not available.

Maynard et al. (2015) identified barriers for equipment use including expense, "built-in obsolescence," lack of temperature and climate controlled facilities, intermittent power supply, and a lack of knowledge and support for maintaining and repairing equipment (p.192). They also proposed that equipment should not be considered in isolation: "the distribution of an integrated set of technologies, rather than separate components, is essential for effective implementation and a substantial impact on neonatal health" (p.192).

Crede, Van der Merwe, Hutchinson, Woods, Karlen, and Lawn (2014) examined pulse oximetry equipment failure as part of their work to consider how best to design a robust and affordable pulse oximeter suitable for use in low-resource settings. Their study reviewed fee tickets for repairs of 1840 pulse oximeters at a repair facility in South Africa. The study data indicated that the fee for repair of one pulse oximeter, to include evaluation, repair, and shipping costs averaged around $53.00 US dollars per repair, a cost that might prove prohibitive to clinics in low-resource settings. Almost all of the pulse oximeters included in their study were

repairable (98% of those included), and the most common defects occurred in the wiring and housing (not in the pulse oximetry components), a finding that indicated that the actual manufacture and choice of the core materials was good. The researchers pointed out that the revenue stream generated by repairs and replacements of pulse oximeters acts as a disincentive for the development of something more durable by vendors. The researchers concluded that while an increase in durability and lifespan of pulse oximeters would be beneficial in all settings, it would be especially impactful in increasing "the accessibility of pulse oximetry for monitoring of lifesaving oxygen therapy in low-resource settings where it is often unavailable" (p.313).

Readily available, affordable and durable pulse oximeters are critical to infant care in any setting, given the difficulties both in clinically diagnosing central cyanosis, and the potential harms, such as retinopathy of prematurity (ROP) caused by giving newborn infants too much oxygen (Wyatt, 2008). The availability of oxygen therapy without good availability of pulse oximetry may contribute to the incidence of ROP Gilbert and colleagues suggested a first and second epidemic of ROP – the first caused by inadequate oxygen monitoring, and the second by extreme prematurity in locations where smaller infants are surviving (Gilbert et al., 2005).

Stepwise Approaches to Care

Given the variety of care settings in which infants may be cared for, and the differing environmental, staffing, and logistical factors influencing that care, it may be helpful to offer a stepwise approach to healthcare providers. Appropriate interventions can thus be chosen based on resources, staffing and setting. The World Health Organization's "Every Newborn: An Action Plan to End Preventable Deaths" ("WHO | Every Newborn," 2014, p. 15) separates care by the level of the setting in which it is given. This plan assigns care of the small and sick newborns to first and secondary level facilities, with emergency care of those same infants relegated to

tertiary and referral facilities. The "Every Newborn" algorithm does not specify individual interventions such as oxygen use, but does include oxygen therapy in a list of interventions that might be provided to small or preterm babies. Oxygen can be provided relatively easily in the primary and referral settings, with intermittent pulse oximetry utilized as resources permit. More advanced interventions such as CPAP, surfactant use, intubation and mechanical ventilation, and pulse oximetry with continuous monitoring are likely to be available only in tertiary facilities.

Training for Workers in Low-Resource Settings

Training for health care workers is often limited, and high-quality video or other teaching resources are difficult to find; especially those aimed at low-resource settings. This lack of teaching resources prompted the launch of GHMP. In addition, trained health care workers may also be in short supply. A review by Blacklock et al. (2016) stated that "Africa bears 24% of the global burden of disease but has only 3% of the world's health workers" (p.1). This review stressed the importance of context in efforts aimed at improving the performance of existing staff: "in order to implement interventions effectively, policy makers need to understand and address the contextual factors which can contribute to differences in local effect" (p.17). The authors concluded that it is "possible to improve the performance of existing health workers serving in under-resourced health systems," while noting that the "wide range of interventions assessed and outcomes measured in very different settings means that a simple comparison of relative effect has limited policy relevance" (p.11). The trials reviewed cited contextual modifiers including the degree of community participation, the motivation of local clinic managers, staff shortages, lack of equipment, and the adequacy of supervision.

Sousa and Meilke (2015) conducted a review of literature related to training in resuscitation in low-resource settings. Fourteen studies were included in the final review. These

studies focused on low-resource countries, addressed some aspect of training in neonatal resuscitation, and reported a mortality effect. Neonatal mortality was the primary outcome for this review; the key research question was defined as "can an educational intervention containing some element of resuscitation training decrease the level of neonatal mortality within the context of a low-resource community" (p. 691). The limitations of this review were mostly in the design of individual studies, which were varied. The review determined that evidence for the benefit of training on neonatal mortality rates is mixed. The studies that included in the review examined institutional settings and at settings where traditional birth attendants may be working independently, while reminding readers that even in institutional settings, resources can be limited. The authors offered three conclusions: 1) training interventions were most effective when resuscitation training was provided within the broader context of essential newborn care (ENC); 2) the most successful interventions were those aimed at health care personnel who were working outside the institution setting (such as traditional birth attendants; and 3) a variety of training approaches may be most likely to ensure that knowledge "becomes embedded in practice" (p. 700). "Considered together, the data would suggest that the best approach may be to make an ENC program containing basic resuscitation steps as broadly available as possible to health care providers" (p. 700). The authors also stressed the importance of considering not only the content of any training, but also the method of delivery, and the opportunity for trainees to refresh and practice new skills.

Ersdal and Singhal (2013) pointed out that "the most up-to-date evidence-based guidelines will not help a single baby, either in resource-limited or high-resource settings, unless they are translated into clinical practice" (p.375). They used the Utstein formula (named for a symposium at Utstein Abbey in 2006), for considering the likelihood of neonatal survival. The formula

includes medical science (that may be expressed as guidelines), educational efficiency, and local implementation as the three contributing factors, where the product of these factors equals survival. (Medical Science x Educational Efficiency x Local Implementation = Survival). Each factor is assigned a percentage value, expressed as a decimal, so that in ideal circumstances survival would equal 100%: 1 x 1 x 1. In 2013 the symposium meeting expressed the belief that the formula for survival "will be useful as a mental framework when trying to improve resuscitation outcome in communities worldwide" (Søreide et al., 2013).

Technology as a Learning and Teaching Tool

According to Pimmer et al. (2014), relatively little is known about the specific uses of mobile technology, including smart phones, to enhance learning in low and middle income countries. Most studies to date that surveyed the use of mobile devices, and "just-in-time" learning, have focused on high-resource settings. Abbott and Coenen (2008) discussed the importance of information technology as one piece of the solution to global health issues. They noted that the benefits of technology may not be fully realized, if implementation of technology-based solutions does not take into account other important factors in developing countries such as poverty, human rights, and workforce development challenges. Further, technology can provide solutions to some challenges, but it cannot solve every problem, and well-intentioned but unsustainable technology interventions in the developing world have sometimes resulted from a mismatch of cultural norms, need, and technologies. Of the 41 trials included in the Blacklock review (Blacklock et al., 2016), only one (Autry et al., 2013) explicitly mentioned video as part of the intervention, the Autry trial was one of several cited by Blacklock et al. as having a substantial size effect.

The potential of video utilization in terms of return on investment and reach, is illustrated by the extent to which GHMP's videos have been disseminated, even within the very short (four years) lifespan of the organization. The 66 completed videos had received over 13 million total views, and over 71,000 downloads in 236 countries and territories as of October 15, 2016 (Cardellichio, 2016). These numbers are likely an underrepresentation of the actual number of views, since it is impossible to accurately measure the dissemination of the videos to groups of health care workers who may watch them together, rather than using an individual download.

Lawn et al. (2009) cited barriers for the training of health care workers including the "lack of capacity and staff with necessary skills for resuscitation, even in countries where more births are in health facilities" and the "lack of supplies, e.g. bag & mask" (p.53). Autry et al. (2013) looked at the use of live video via internet for teaching surgical skills in a low-resource settings and concluded that "remote teaching in low-resource settings, where faculty time is limited and access to visiting faculty is sporadic, is feasible, effective, and well-accepted by both learner and teacher" (p.127). While Autry et al. focused on the use of interactive teaching, rather than video that can be accessed by the learner at will without direct interaction with a teacher, the use of video in general can allow those who are not able to travel to participate in global health education. They also noted that clinical faculty can be in short supply and have limited time to devote to teaching; video in these cases can be a useful adjunct. One potential advantage of the use of videos such as those produced by GHMP is that they remain accessible to health care workers on demand, provided that there is the online access or download capability.

Benner (2001) outlined five progressive learner modalities: Novice, Advanced Beginner, Competent, Proficient, and Expert. As the learner moves from Novice towards Expert, they also move from needing guidance and rules, to a more intuitive workflow and decision-making

process in practice. The challenge for this video script project was to create script content that would be relevant both for community health workers and more experienced healthcare professionals, as well as allowing those at a variety of places on Benner's continuum to benefit. The audience for these videos may already have ample experience in the situations within which they are expected to work, but have a limited knowledge of best practices. Conversely, for healthcare workers from higher-resource settings, or viewing the video from within the context of a more developed country, there may be a lack of expertise or experience in low-resource settings. The videos developed by GHMP are viewed in many different settings and contexts, and on occasion are adapted for the particular needs of a clinical setting. Therefore it is not feasible to tailor a script solely to one audience or to assess where potential viewers are at multiple places on a scale of readiness to benefit from the information.

Frehyvot et al. (2013) identified a variety of e-learning modalities within health education. Of relevance to this project were internet-based learning, mobile learning, and the concept of a digital library, or collection of resources that can be utilized by students for just in time learning. One of the strengths of a digital library in the context of health care is the ability of learners to view resources multiple times as a way of reinforcing concepts and best practices. Those who do not have Internet access in the field can view resources that are downloadable remotely if they have access to a Smartphone or tablet. Allowing videos to be open source promotes the widest-possible distribution. Open sourcing and sharing can make it challenging to measure reach, and there are some outstanding questions about the potential need for fee for service options when videos are re-distributed by other organizations. These financial considerations and questions were not further addressed by this project.

Cole et al. (2011) have discussed the cultural competencies required by those working and conducting research in the field of global public health. “Skills in cross-cultural communication and the ability to critically self-reflect on one's own social location within the global context are essential. Those in global health must be committed to improving health equity through global systems changes and be willing to be mentored and to mentor others across borders” (p.394). Of relevance to the development of video designed to aid healthcare workers within their own cultural settings was the competency addressing sensitivity to cultural differences and local contexts, identified by the University of Toronto for their Master of Public Health degree (cited in Cole et al., 2011, p.395). *Making Health Communication Programs Work* (1989, updated) includes a useful discussion of what constitutes culturally sensitive communication: “substituting culturally specific images, spokespeople, language, or other executional detail is not sufficient unless the messages have been tested and found to resonate with the intended audience.” (p. 60). The challenge of video that is aimed at multiple settings is to provide that sensitivity and adaptation in a way that is also universally accessible, rather than specific to just one cultural context. The use of voice-over, information presented in as simple a way as possible, and the presentation of one idea at a time helps to mitigate cultural differences and ensure that scripts and video footage can be used widely. The *Making Health Communication Programs Work* guide also discusses the need to carefully balance the preservation of scientific accuracy with the need to ensure that the intended audience can easily understand the language and concepts of any health education or communication resource.

Conclusions

The consensus appeared to be somewhat divided about which interventions are most appropriate in low-resource settings. Oxygen can be expensive, and difficult to monitor (if pulse

oximetry is not easily available). Initial discussion with content experts indicated that more information about its use and the use of pulse oximetry equipment would be widely welcomed. Further review of the literature and discussion with content experts was helpful in determining barriers to use, best practices in avoiding complications such as retinopathy of prematurity, and safety considerations.

A stepwise approach to interventions may be helpful, based on available facilities and staff. The majority of infants can be successfully aided with simple interventions, with only a small minority requiring advanced resuscitation support such as chest compressions, intubation, or medication (Wall et al., 2009). There appears to be a middle ground between the most basic of interventions (warming, drying and stimulation), and the fully-fledged neonatal intensive care unit (NICU). It might be argued that primary care settings and small referral hospitals fall into this middle ground – and could benefit from additional training and resources around the use of interventions such as oxygen and simple bubble CPAP machines.

It seems clear that equipment, whether donated or purchased, cannot be considered in isolation. A careful assessment of the context within which it will be used, the training required, and the ongoing maintenance needed, contribute to any determination of whether or not it will provide benefit. The development of a rubric by which potential technologies and interventions might be measured could be helpful in determining which would be most likely to function successfully in low-resource settings.

Video resources focused on the safe use of oxygen in low-resource settings are lacking, notwithstanding the fact that oxygen may be one of the few drugs or interventions available in such settings. Any video needs to be scripted and filmed within the framework of the cultural and educational contexts in which it is most likely to be viewed. Given the wide reach in terms

of viewership, GHMP video scripts benefit from the use of voice-over, and from use of clinical scenarios that are specific to low-resource settings, but not so specific to one cultural context as to exclude others. The World Health Organization *Guidelines on Basic Neonatal Resuscitation* (2012, p.44) identified several questions for future research that have specific relevance to the topics addressed by this project, two of which related to the use of video as a teaching tool and the challenges of training healthcare workers: "What is the effect of video recordings of the care provided to a newborn at birth as a teaching and evaluation tool? What is the trainability and performance of different categories of health workers in conducting resuscitation?" While this video script project was not research-based, these questions were helpful reminders of some of the key issues that have emerged around the topic of training and the use of technology in low-resource settings.

Chapter III

Methods

This project was intended to create a video script, outlining best practice in the use of oxygen for infants in low-resource settings. This chapter reviews the need within low-resource settings for video teaching aids, outlines the plan used for script development and review, and considers evaluation methods.

Identification of Need

Deborah Van Dyke, FNP, MPH, a nurse practitioner with extensive experience in low-resource settings developed GHMP as the result of her numerous experiences garnered during her work with Doctors Without Borders. During her work in low-resource settings, Van Dyke found herself providing teaching to local health-care providers. As described by her, she assumed that video resources would be easily available, yet a search for quality video resources specific to her needs and to low-resource settings revealed few options. GHMP's video series was conceived to meet this gap. The videos are aimed at health care providers (and community members including parents). They are filmed in, and relate to, low-resource settings, using real-life scenarios and patients, families, and health care workers.

Review of Existing Models

As discussed in Chapter 2, a review of the literature revealed few studies that examined video resources for teaching health care workers within low and very-low-resource settings. Autry et al. (2013) cited the utility of video as a teaching tool in remote settings, where access to education and faculty may be scarce. The Mental Health Gap Action Program (mhGAP) offers training videos that feature mental health programs in a variety of low-resource settings. Videos developed by mhGAP aim to demystify a variety of mental health conditions, including epilepsy,

developmental disorders, depression, and suicidality. The videos differ somewhat from those produced by the GHMP. They feature a variety of scenarios, and are accompanied by related training materials. The "patients" are actors. It is interesting to note the predominance of male doctors appearing as care givers, often in white coats, and seated behind a desk, or in a setting that could imply a power differential between patient and provider. The mhGAP video series features several modules, designed to be viewed sequentially. The accompanying Intervention Guide, was developed "through a systematic review of evidence followed by an international consultative and participatory process ("mhGAP Intervention Guide," 2014)." The introduction to the guide and the rationale for the videos and training suggests that mental health interventions can be delivered in low and middle resource settings that do not need to be specialized. The guide presents interventions that are recommended for these settings (p.1). Although the interventions suggested are brief, the guide is aimed at health care providers, and the resource guide is fairly text heavy – a useful resource, but more complex than the level of intervention that GHMP proposes.

Medical Aid Films (MAF) provides videos that have similarities to those produced by GHMP. Their mission is to use "film and innovative media to transform lives, so that every woman and baby around the world can survive and thrive (Medical Aid Films, n.d.-d)." Like GHMP, their videos focus on both healthcare workers and community health education, and cover newborn care, community infections such as Ebola, and a variety of other topics. Their videos are available in multiple languages.

Medical Aid Films video topics for health workers and community education workers include "*How to care for a newborn baby: the first hours after a baby is born*," "*What to do when a newborn baby is not breathing."* In some cases, the videos appear to be aimed at even

more remote settings – those when even basic community health care may not be available. For example, the video entitled "*What to when a newborn baby is not breathing*" assumes no special equipment, apart from gloves, and recommends mouth-to-mouth resuscitation without a shield for a baby that is not breathing. Another series of MAF videos devoted to Emergency Obstetric and Neonatal Care which includes "*How to Resuscitate a Newborn Baby,"* a 20 minute film for health care workers. There was no video or resource on the safe use of oxygen in the MAF video library as of July 2016 (Medical Aid Films, n.d.-a, n.d.-b, n.d.-c).

Empowering local health care providers through teaching basic, and more advanced skills allows for practice improvement and the implementation of sustainable change while avoiding some of the logistical problems inherent in providing assistance in person through visits to healthcare providers, or through the donation of equipment. The Tropical Health and Education Trust (THET) outlined some of the challenges of donating equipment in a video entitled "*Making it Work: Managing medical equipment in low-resource settings"* (THETpartnerships, n.d.). THET noted that equipment donations are often not well thought out, and lack planning at the outset for equipment maintenance, procurement of spare parts etc. They stressed the need for training, purchase of spare parts and inclusion of manuals at the point in time when equipment is being purchased, to avoid problems associated with obsolescence and supply chain difficulties.

Some of the THET's work has been focused on the training of biomedical engineers working in low and medium resource settings, with the goal of building the capacity for equipment repair and maintenance in the field. They noted the need to cultivate relationships, not only with the recipients of donated equipment, but also with suppliers, customs officials, and freight companies among others. And they stressed the need for an "equitable relationship…jointly developed" between donor and recipient organizations (THETpartnerships,

n.d.). The process of building a video script requires the translation of this "equitable relationship" into a medium that is in many ways a one-sided interaction – a video that is intended to be viewed by healthcare workers. Cultural humility and awareness is paramount during the process both of script development and filming; counteracting and attempting to at least partially balance the potential one-sided relationship between video developer and audience.

Development of Project Material

An initial review included all existing GHMP videos, as well as other healthcare videos, including those produced by MAF. In addition to reviewing video content, tone, setting, language and other aspects were considered. International guidelines on neonatal resuscitation and the use of oxygen in neonates were reviewed. The National Guideline Clearinghouse, the WHO, and ILCOR served as primary resources. Key points from each guideline were entered into a spreadsheet for comparison and consideration.

A review of the literature focused on oxygen use for respiratory distress, and in neonatal resuscitation, and on the use of oxygen and other equipment in low-resource settings. In addition, literature pertaining to the use of video as a healthcare teaching tool in low-resource settings was considered. Content experts were consulted about the need for a video on oxygen use, and about best practices in neonatal resuscitation, respiratory therapy for premature infants, and healthcare practices and needs in low-resource settings. The project's relationship to advanced practice nursing was considered in the context of nurse practitioner as well as global and public health competencies.

Reviewing the GHMP videos already in existence revealed the following commonalities, which helped to guide this script development:

- A clear title and specific goal of each video
- A brief explanatory overview of what the video will show and why it is important
- First steps – for example, hand washing or gathering necessary equipment
- An explanation of what is happening in the clinical scenario depicted, including what can be seen when assessing the baby, and what to look for
- A description of what the health worker should assess for and how to do complete each step of the assessment, including specific techniques
- A brief and clear description of what the problem is. For example, "this baby is too cold."
- Demonstrations of what care and interventions should be provided and how to give treatment
- Instructions on what is important to communicate to the mother or caregiver
- A review of any warning signs in the baby
- A clear timeline for when see the baby back or when to reassess
- Instructions on when to refer and in what circumstances
- Visual aids to help reinforce key points
- A review of key points at the conclusion of the video
- Clear, simple language with short sentences
- Succinct communication of each point, with a focus on one point at a time
- Narration and video that progress at a pace that allows for easy comprehension
- Visual/graphic cues for key learning, that reinforce through the spoken script.

These common attributes contribute to the creation of a product that is versatile. Simplicity, both of the teaching points communicated, and the manner in which they are presented, helps

keep the learning objectives foremost. This approach also allows for easier adaptation of videos to other languages – with ample time for explanations. As discussed in Chapter 1, the script consists entirely of voice-over, rather than any direct dialog, making translations into other languages easier. Above all, clarity and simplicity of information is key. In the initial planning stages for this video script the decision was made to limit this particular video to safe oxygen use – ensuring a clear and specific goal. Learning points need to be communicated one at a time, and in a logical order. The visuals – both video footage and any graphics – must be incorporated in a way that best reinforces the information being conveyed.

Content. Developing a script specific to oxygen use began during the review of literature. Evidence-based clinical guidelines pertaining to the use of oxygen in infants were gathered and assimilated. In preparation for script development, key information from relevant guidelines was entered into an spreadsheet for ease of comparison and reference. Using a simple storyboard draft script language was developed. This storyboard was then split into several shorter sections– each limited to a specific topic. Once these were complete, this information was translated into a more traditional script format, as specified by GHMP and conveyed to the organization as a draft.

As noted in the literature review, numerous clinical algorithms exist – the challenge for this project was to choose how to communicate key points; teaching and reinforcing the concepts in a way that was as universally accessible as possible, and simple enough to convey in a short video. Guidelines were studied, and condensed into a number key teaching points. The focus was on identifying the baby who requires oxygen, and on how to administer oxygen safely in order to prevent or minimize any damage caused by over oxygenation. Since pulse oximetry and other means of measuring oxygen saturation are not consistently available in low-resource settings, the

script also focused on safer ways to provide oxygen when monitoring is not available while ensuring, to the greatest degree possible, that a baby is not over-oxygenated. The teaching points included:

- Overview of oxygen use and need
- Determining the need for oxygen in a baby, using a pulse oximeter or by conducting a clinical assessment looking for signs of low oxygen
- Using a pulse oximeter if one is available
- Using nasal prongs to deliver oxygen
- Using a nasal catheter to deliver oxygen if nasal prongs are not available
- Assessment of the baby who is receiving oxygen
- Steps to take if a baby is not improving
- Discontinuing oxygen and discharging the baby

The script elements outlined earlier served as an organizational starting point. The content was focused on the use of oxygen only, including the clinical parameters and best choices for technology and delivery devices that may be available within low-resource settings. The technology discussed was be limited to basic oxygen administration, and intermittent monitoring with pulse oximetry.

Once all teaching points were identified and a draft outline complete, the script was analyzed for accessibility as detailed below. It was timed, with the goal of a finished video product of no longer than 7 minutes. A draft script was sent to content experts for their input and analysis.

Enhancements or Inhibitors in Implementing Project Objectives

Inhibitors. The 2015 CoSTR recommendations (Wyllie, Perlman, et al., 2015) considered the following question, posed in PICO (population, intervention, comparison,

outcome) format: “In neonatal resuscitation instructors (P), does formal training on specific aspects of how to facilitate learning (I), compared with generic or nonspecific training (C), change clinical outcome, improve all levels of education or practice (O)?” (p. 24). The consensus recommendation stated that the training of neonatal resuscitation instructors should include written or verbal feedback that is individually-targeted, timely, objective, structured. A video cannot provide the type of targeted and specific feedback to any viewer that is possible with other teaching modalities. While this could be considered an inhibitor, it is also worth noting that a good-quality video can serve to enhance other teaching modalities – providing valuable visual representations of the skills to be taught and learned.

The timeline for creating this script was not ideal, given GHMP’s filming schedule for 2016. Some footage was obtained early in the year, prior to completion of this full script. While this footage may comprise part of the ultimate video, it may not be sufficient to accompany the script in its entirety.

Participants

Participants in this project were the student-author, GHMP, and content experts familiar with neonatal care, respiratory support for newborns and/or healthcare practice in low-resource settings. The video audience is intended to be healthcare workers in low-resource settings. The context within which these healthcare workers function may vary, depending on location, current resources, and local public health organization. It is anticipated that all those viewing the video will be involved in the care of newborns in some way. In addition to the target audience, others may view the video for a variety of reasons. These additional viewers may include families, healthcare workers and students in other settings, including those with higher levels of resources, and community and public health personnel. The audience for the video will be either self-

selected based on the open sourcing of GHMP's videos, or may potentially be introduced to the video by health care organizations or through training courses that utilize GHMP's videos are resources.

This project was limited to the video script development only. If and when the video script is filmed, additional participants will have direct involvement through their appearance in the videos. The GHMP crew films most videos on site in low-resource communities around the world. In almost all instances, patients shown in the videos are actual patients, not actors. In addition, providers are drawn from the community within which the videos are filmed. Some scenes may, if feasible, be shot in the United States; provided that the demographics of those filmed – both patients and healthcare providers – reflect the demographics of the intended viewers. In additional the settings and equipment used need to replicate what might be encountered in a low-resource setting in a developing country. Throughout the process of script development cultural context and potential personal, organizational, and guideline biases were considered as they relate to this project. Cole et al. stated "skills in cross-cultural communication and the ability to critically self-reflect on one's own social location within the global context are essential (Cole et al., 2011, p. 394)." procedures are in place within the GHMP for obtaining filming consent; these will be followed in the event that the script developed for this project goes into production.

Plan for Evaluation

All information presented in the script was drawn from a combination of guidelines approved by expert medical organizations (WHO, AHA, ILCOR). Elements of the content and presentation of the script were reviewed at various stages during its development, by an invited panel of content experts:

- **Carol Buck-Rolland**, Ed.D., APRN, Clinical Professor and Graduate Program Director, Nursing, University of Vermont
- **Christopher Chambers**, RRT, Supervisor Respiratory Care, University of Vermont Medical Center provided valuable background information to the student author on current best practices in higher-resource settings.
- **Danielle Ehret** MD, MPH, Assistant Professor of Pediatrics University of Vermont Children's Hospital; Director of Global Health, Vermont Oxford Network provided initial input and reviewed the final script.
- **Deborah Van Dyke**, FNP, MPH, Founder of Global Health Media, provided feedback and guidance. Her input as a clinician with experience filming "on the ground" in low-resource settings helped to focus script elements.
- **Hendrika Maltby**, Ph.D, RN, FACN, Professor of Nursing, University of Vermont
- **David Woods,** M.D., Emeritus Professor, Neonatal Medicine, School of Child and Adolescent Health, University of Cape Town, Cape Town, South Africa. Dr. Woods had initial input, and was one of the proponents of providing a teaching tool related to oxygen administration in low-resource settings.
- **Videographer – to be identified.** A videographer will also review the script at the point that GHMP decides to go into production. This will ensure that content is appropriate for filming, and that sequences fit well for editing purposes.

The ultimate success of this video script project will be measured by whether the script itself is made into a teaching video, while recognizing that this is dependent on budget and other resources beyond the control of the author. Content expert review points and revisions were incorporated based on their feedback. It was not possible to evaluate outcomes fully, as this not a

research study looking at a specific intervention within the setting of a randomized controlled trial. Success may be measured on access to the information contained in the video script by health care workers, and on the reach of the video. Actual patient care outcomes and any impact on patient care and neonatal survival are difficult and may be impossible to measure and to extrapolate.

Reach can be estimated by tallying total video views. GHMP currently measures reach by counting the number of video views and downloads from their website. This is an imperfect measurement tool, as downloads may be shared multiple times, and videos may be viewed by several people at one time. One "view" does not necessarily constitute a view by one individual. Requests for permission to translate the video narration into other languages are received by the GHMP; while they aim to maintain some control over how this is done, this can further extend the reach of the information they provide in ways that it is not possible to measure accurately. Some evidence that videos are being used in the intended context and on their efficacy can be obtained through anecdotal feedback.

Accessibility. The Suitability Assessment of Materials (SAM) scoring tool was also be used both to score the script, and as a benchmark and guide during the writing process. Although the SAM was initially aimed at evaluating written health materials, it has also been used to assess video and other media. SAM was validated with health care providers from a variety of cultures, as well as students and faculty from the United States. It provides a rubric for scoring educational materials based on six broad areas: content, literacy demand, graphics, layout and typography, learning simulation and motivation, and cultural appropriateness (Doak, Doak, & Root, 1996).

To ensure that language used was compatible, the script was evaluated using the Text

Readability Consensus Calculator, a readability software tool (available free at http://www.readabilityformulas.com/free-readability-formula-tests.php). The calculator initially ascertains the word, sentence, syllable and character count in a sample of text. The resulting calculation is then inputted to seven readability instruments/metrics: Flesch Reading Ease Formula; Flesch-Kincaid Grade Level; Fog Scale, SMOG Index, Coleman-Lau Index; Automated Readability Index; and Linsear Write Formula. This gives an approximation of grade level, reading ease, and complexity.

During the script development process online guides available from the Centers for Disease Control and Prevention and the National Institutes of Health on clear communication in healthcare publications, as well as the Federal Plain Language Guide were consulted. ("Federal Plain Language Guidelines," 2011, "Making health communication programs work: A Planners Guide," 1989, "Simply put: a guide for creating easy-to-understand materials (Third Edition)," 2009) Simplicity of language will not only help English speakers to understand the script, even if their proficiency level is less than fluent, but should also help to ensure ease in future translation, should this be desired.

Internal Review Board (IRB) Approval. This project was approved as "Not-Research" by the University of Vermont IRB on April 29, 2016. See Appendix II.

Summary

This project produced a script suitable for a short, educational video aimed at providing frontline health workers in low-resource settings with knowledge and skills related to the use of oxygen in premature infants with respiratory difficulties. The script considered best practices as identified in the literature, with consideration of resources commonly available in low-resource settings.

Chapter IV

Evaluation and Discussion

Achievement of project objectives reflect results of evaluation

As described in the introduction, the aims for this project were twofold:

Aim 1: Develop a script for a five to seven-minute video on safe oxygen use, to be produced by Global Health Media for inclusion in their small baby or newborn video series.

A five to seven-minute video script addressing oxygen use for infants in low-resource settings was developed. In addition, a separate shorter script that addresses oxygen safety and storage was created as an adjunct to be used as reference or as a separate video if desired. The literature review comprised a large part of the preparation for developing the video script. Guidelines, publications by the WHO and others, as well as individual studies contributed to the development of the student author's understanding of the scope and implications of this particular video script. During this review, the focus of the video script shifted, informed by the literature review, and further discussion with GHMP. The script ultimately focused on oxygen use for respiratory distress in infants, with brief reference to the possibility of referral for more advanced care, for those infants who require it. This narrowed and specific focus for the script was consistent with the Centers for Disease Control and Prevention (CDC) guide, *Simply Put* (2009), which recommends limiting the number of messages conveyed in one communication.

Aim 2: Increase access for health care workers to the information and skills they need to provide oxygen safely to babies with respiratory distress who are seen in the community, primary care and referral settings.

The achievement of the second aim for this project is dependent on the ultimate production and distribution of a video resource. The script was developed with this goal in mind,

and attention was paid to best practices not only in the clinical setting, but also as they relate to online training and delivery of information to healthcare workers, with a focus on low-resource settings. This is discussed further in the section on text analysis that follows.

Script Development. The script was limited in length – since the final video product has a proposed length of five to seven minutes. In addition, consideration needed to be given to how much information could reasonably be conveyed effectively through the video, and what degree of complexity should be offered. This type of video is not the best method for in-depth analysis or discussion of nuances in care decisions, but needs rather to offer a clear, concise overview that can be usefully translated to practice. The final script was divided into broad sections that covered: a basic overview of information about giving oxygen, including a very brief discussion of the dangers of giving too much oxygen; assessment of hypoxia in infants – both through pulse oximetry and clinical signs; delivery methods (including nasal prongs and nasal catheters); the assessment of an infant who is receiving oxygen; simple troubleshooting; discontinuing oxygen, and when to discharge an infant; the possibility of referral; and a review with repetition of key points. The additional script considering oxygen safety outlines generally accepted safety provisions, including oxygen storage and daily checklists for any health facility using oxygen.

Review by Content Experts. A draft of the script was sent to Van Dyke and to two content experts for review. Along with requesting a general review of the script, questions sent to content experts for further clarification included queries about best practices, logistical issues pertaining to low-resource settings, and the degree of depth of information. At the time of this writing detailed feedback has been obtained from Danielle Ehret, MD, MPH, Assistant Professor of Pediatrics, University of Vermont Children's Hospital Division of Neonatology and Director of Global Health at the Vermont Oxford Network. Ehret is also a Master Trainer for the Helping

Babies Breath program and has helped to educate local birth attendants in Rwanda. Ehret's feedback can be found in Appendix III.

Information gathered by GHMP in conjunction with an additional content expert, was also compared against the script developed for this project. The content was largely congruent, with the exception of one area of discrepancy identified in the delivery methods section – related to the use of nasal prongs versus nasal and nasopharyngeal catheters. This prompted further review of evidence and literature around this issue. While nasal and nasopharyngeal catheters are viable options for the delivery of oxygen, the consensus of the WHO and others is that nasal prongs should be the first choice of delivery method. The WHO recommends that catheters should only be used where nasogastric tubes are available, and for nasopharyngeal catheters where humidification is also available (see literature review for further discussion).

Text Analysis. The draft script was analyzed using the SAM, adjusted to suit the video format as suggested by its authors (Doak et al., 1996). The SAM score for the script was calculated at 22/28 or 78% (Appendix IV). Doak et al. rate scores of 70-100% as superior, with scores of less than 40% indicating material that is "not suitable." Doak et al. recommended reading formulas, which are included as one of the tool components, as a "reasonably accurate measure of reading difficulty" (p. 53). They suggested that all materials be written at the 8th-grade level or less, and proposed that readability should be a "go/no-go" measurement for materials. It is useful to note that the CDC's (2009) *Simply Put* guide qualifies readability formula results, noting that they "do not measure a person's level of comprehension. Comprehension levels are often two or more grades below reading or education level. Comprehension drops even more when a person is under stress" (p. 27).

The SAM tool suggests the use of interaction within the text – for example posing questions or problems that the reader or listener can respond to, or using questions and answers – and the script scored a zero in this regard. While specific examples will be shown in the video, demonstrating how a baby with low oxygen might present for example, the video format lends itself less readily to interaction. This is something that might be considered further once actual footage has been obtained. GHMP's video on fast breathing uses interaction, with viewers asked to count the breaths per minute that a baby is taking. Similar interaction might be used in this video on oxygen, with viewers asked for example to identify clinical signs of respiratory distress.

The SAM tool also contains a section on "cultural appropriateness." Although much will depend on the actual footage used, all of GHMP's videos do use culturally appropriate images and examples. In addition, efforts were made through both the literature review, and content expert consultations, to ensure that the script is relevant to the target audience in low-resource settings.

Limitations of this analysis were the design of the SAM tool for education materials aimed at a lay audience, and the unavoidable inclusion of technical language in the script, which skewed the reading levels. As the Federal Plain Language Guidelines (2011) make clear, technical or advanced language cannot always be assumed to be inappropriate: "The first rule of plain language is: write for your audience. Use language your audience knows and feels comfortable with. Take your audience's current level of knowledge into account." (p. 1) The audience for the GHMP videos includes health professionals for whom English is not a first language, and who may have limited training. Technical language aside, the SAM tool, and the Federal Plain Language Guidelines provided useful insights, ensuring that the active voice was used wherever possible, style was consistent with easy readability, and that context was provided

for directions. Doak et al. (1996) stated that when the context is provided first, new facts and behaviors are learned more quickly. They provided the following example: "To find out what's wrong with you (the context first) the doctor will take a sample of your blood for lab tests (new information)" (p.54). In keeping with Federal Plain Language Guidelines, this video script (and others produced by Global Health Media) uses the pronoun "you" and addresses the viewer directly. For example: "When you insert the catheter, aim slightly up and then straight backwards," as opposed to "the catheter should be aimed slightly up and backwards."

Challenges

One of the challenges of this project was the need to narrow the focus and content of a video script to five to seven minutes, and deliver clear, accurate content relevant for providers in a variety of settings. Following a literature review, the initial script ideas were divided to focus on several different areas:

- Equipment, including type, maintenance, use, and safety considerations for storage of oxygen
- Dosage of oxygen, safety in administration
- Assessment of the newborn at birth and use of oxygen with positive pressure ventilation as part of the resuscitation procedure
- Assessment of an infant that is breathing independently, but is showing signs of hypoxemia

Equipment included in the script needed to be guided by necessity anticipating what is most readily available in the field, recognizing that it would be impossible to cover all potential equipment set-ups. Safety issues are more universal when it comes to the logistics of safely

storing oxygen. There are separate safety issues around its administration, related to dosing and delivery.

In moving from the literature and guideline review to the actual development of a script for health workers, it became clear that there was a need to separate oxygen use during neonatal resuscitation in the delivery room, from oxygen use for infants with respiratory distress who may require ongoing oxygen. Although an infant who requires resuscitation at delivery may also require ongoing oxygen support, the initial provision of oxygen in the delivery room differs from the provision of ongoing respiratory support. The assessment of a premature infant may also differ, depending on when the baby is assessed, and the equipment on hand. For example, guidelines for rapidly assessing a baby at birth focus on gestational age, independent breathing or crying, and the number of breaths per minute (Wyckoff et al., 2015b; Wyllie, Bruinenberg, et al., 2015; Wyllie, Perlman, et al., 2015). The ongoing assessment of oxygenation may be achieved through use of pulse oximetry (preferred) or of other clinical signs such as chest retractions, nasal flaring, and central cyanosis (Eberle, Trujillo, & Whitaker, 2015; Maternal and Childhealth Advocacy International, 2015; World Health Organization, 2013). In the delivery room, providers need to make the assessment right away as to whether to initiate resuscitation with room air or oxygen – this being dependent on the gestational age and size of the newborn. Since oxygen is given by bag and mask during initial resuscitation, a blender is needed so that the oxygen concentration is kept to the recommended level 30%. When giving ongoing oxygen as part of respiratory support, 100% oxygen can be used, since it is delivered by nasal canula or catheter.

Oxygen use in the delivery room is something that may be outside the scope even of many referral hospitals in low-resource countries. Van Dyke further clarified that the use of

oxygen in the delivery room is not addressed in Helping Babies Breathe, and is not commonly seen in the hospitals in which GHMP films. Therefore the main thrust of the video script was adjusted to address oxygen delivery outside the delivery room. A separate shorter script was also developed that addressed safety issues related to oxygen use; with the goal of providing basic safety information that can be included in any video relating to oxygen use as needed.

Clinical assessment skills are reinforced through the video script, and through other videos already available online. Effort was made to ensure that clinical skills are consistent across videos, for example assessment of the baby with respiratory distress. In addition to providing consistency for trainees/video audiences, this also makes economic sense, as video footage can be re-used for specific assessment examples if needed. It can be challenging to obtain good footage of specific clinical conditions (for example nasal flaring, grunting, central cyanosis). Whether footage needs to be re-used or new footage can be used will depend on clinical scenarios encountered during any subsequent filming.

Implications for practice, education, and/or research

The video script for this project focused primarily on the safe provision of oxygen to infants requiring respiratory support. It deliberately excluded the use of oxygen in the delivery room, and the use of more advanced resuscitation and respiratory support techniques. As technologies for assessing and supporting infants become more universally available, even in low-resource settings, videos or other educational materials addressing their use may be needed. Currently, oxygen is not typically available in the delivery room in the low-resource settings that GHMP uses for filming. If this changes, and oxygen becomes more ubiquitous in this setting, there may be a demand for resources on its use specific to delivery-room resuscitation.

Limitations of Project

The finished video script is necessarily limited by the length of a typical GHMP video, which is deliberately short and focused on delivering key information succinctly in a manner that allows it to be translated into work in the field. Such videos are not the best vehicle for delivering the subtleties of clinical decision making unique to a particular patient or clinical situation. A short video script is insufficient to convey all of the potential nuances of oxygen administration to infants, even in simplified form. The goal of the project was to produce a script that had utility, and that could impact clinical practice. The videos and this oxygen delivery script aim to distill practice guidelines, evidence from the literature, and experience from the field into clear teaching tools that are accessible and relevant to a range of healthcare settings.

Video footage is obtained on location by the GHMP team. The patients and families portrayed in the videos are those who agree to appear, and who present for care while GHMP is filming. This limits what footage may be available. Therefore the script itself may need to be modified in production. As the footage is edited and paired with voice-over, changes may also be made, and exact wording may be modified in the finished product. The video voice-overs used may be translated into local languages. For example, the animated video produced by GHMP on cholera has been translated into 31 languages. Therefore there is real potential for meaning and specifics to be lost in translation. This limitation was addressed to the extent possible, through use of readability calculators and guides to clear language (see above) in an effort to make the script as amenable to translation as possible. Oversight of translation is by GHMP, although Van Dyke has indicated that this is one area where their available resources are currently stretched (Personal Communication, 2016a)

The videos produced by the GHMP have a wide reach, with video views recorded in 236 countries and territories, and 13 million recorded views as of September, 2016 (Cardellichio, 2016). The audience includes individual healthcare workers, non-governmental organizations, teaching institutions, health facilities, ministries of health and others. Given this diversity, it was impossible to tailor the script to a specific audience. However, this student author aimed the content at the two groups specifically identified by GHMP, frontline healthcare workers and their patients in low-resource countries.

Comparison of Project Outcomes with Review of Literature

The WHO Manual on oxygen therapy for children (2016) detailed assessment techniques and oxygen administration guidelines, with a focus on low-resource settings. The guidance in the manual provided a basis for this project's video script, which focused in equal parts on the assessment of an infant who may require oxygen, and the actual administration of the oxygen. This video script was aimed at healthcare workers in settings where even pulse oximetry may not be universally available. Although pulse oximeters are becoming more affordable and accessible, it is not yet reasonable to expect that they would be available in all settings or in sufficient supply to enable continuous monitoring. Thus, clinical signs of respiratory distress are useful and necessary in assessing infants, and were detailed in the final script.

The literature was clear that nasal prongs or cannula are the preferred delivery method in low-resource settings, given their ease of application and use without needing to add a nasogastric tube or humidification (Rojas-Reyes et al., 2014; "WHO | Oxygen therapy for children," 2016). The ultimate decision about whether to include nasal catheters in the video may depend somewhat on practice and availability in the settings in which GHMP films. The choice is largely immaterial in terms of efficacy - this is an area where cost and convenience may play a

larger role. The question of whether a nasogastric tube is an absolute requirement when a nasal catheter is used is one that was also posed to content experts. Ehret noted that while this is not always seen in the field, it is best practice, as such she felt that the script should recommend it.

This video script offers one modality for training, one that can ideally supplement any training offered to healthcare workers in the field. GHMP's videos are viewed in a wide variety of contexts, and as noted previously the GHMP format lends itself well to translation into other languages as needed and appropriate. When realized as a video, this script will be offered to healthcare workers in the context of GHMP's video series on newborn care. This fits with the concept of a digital library identified by Frehyvot et al. (2013), and with Sousa and Meilke's (2015) assertions that training may be most beneficial when offered in context, aimed at healthcare workers outside traditional medical settings, and conveyed using a combination of approaches.

Conclusions

This project culminated in the creation of a brief and succinct script on safe oxygen delivery to infants, based on a review of the literature and current best practice guidelines, and aimed at healthcare providers in low-resource settings. Content experts helped to guide the information gathering process, identify where best practice guidelines may differ from work in the field, and to hone the script wording itself for clarity and simplicity.

The script was aimed at infants with respiratory distress who require supplemental oxygen. It addressed: measurement of oxygen levels in an infant using both pulse oximetry and clinical signs; use of oxygen equipment, pulse oximeters, and delivery devices; simple trouble-shooting techniques; ongoing assessment; weaning and discontinuation of oxygen. Reference

was made to the need for referral for babies for whom the simple provision of oxygen is insufficient, with the recognition that referral may not always be an option.

The potential of new technologies for assessment and care in low-resource settings is expanding, and is likely to open new avenues of health care worker education and patient care. Examples include: MedSinc, a point of care clinical assessment tool that runs on web-enabled mobile devices; and Powerfree Education Technology (PET), which is working on the development of affordable pulse oximeters and other equipment that is not dependent on a power supply, and is robust enough to withstand environmental stresses ("PET Life-Saving Devices," 2016, "THINKmd: expanding access to healthcare globally," n.d.). CPAP, as noted earlier, is a relatively simple concept with life-saving potential that may also become more commonplace in low-resource settings. These developments have the potential to change how care is provided in low-resource settings. Video content created by GHMP may in turn be delivered in new ways as technology advances.

While technology and delivery mechanisms may change, best practices regarding communication and the development of educational materials remain more constant – requiring only adaptation to new methods of delivering information. Clarity of language and vocabulary, organization of ideas, and simplicity of focus are key whether the medium used is print, in-person communication, video, or online content.

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Appendix I

Video Scripts

SCRIPT 1: ASSESSING THE BABY WITH RESPIRATORY DISTRESS AND GIVING OXYGEN	
SCRIPT	**Footage and Notes**
Introduction Most babies will start to breathe well after birth. However, problems with breathing are a leading cause of death in newborns. Some babies need oxygen immediately after they are born, and in the first few days of life to help with these problems. Babies who are born early or preterm are more likely to have difficulties breathing. A baby that does not get enough oxygen may have brain damage. However, too much oxygen can also be dangerous, especially for babies that are born early. This video shows you how to recognize when a baby needs oxygen, and how to give oxygen safely.	Introductory shot of baby receiving oxygen, or of healthy newborn.
Measuring Oxygen Levels in a Baby The best way to measure whether a baby is getting enough oxygen is with a pulse oximeter. This machine uses a light sensor to measure the amount of oxygen in the baby's blood. This is known as the oxygen saturation (or SpO2.).	Picture or diagram of a pulse oximeter/s. Ensure this the pulse oximeter is a type used in the field. If possible show variations. Include a pulse oximeter that wraps around the baby's wrist or foot.
Using a Pulse Oximeter Turn the machine on. Attach the probe to the hand, wrist, or foot of the baby. For a newborn baby it is best to use the baby's right wrist. If you use a probe that wraps around the baby's hand or foot, make sure that the lights on the probe line up on top of one another. Read the oxygen percentage and pulse when the baby is calm and the pulse is steady. Some pulse oximeters will also show you the pulse tracing.	Health care worker turning on the pulse oximeter. Show how to wrap the probe around the right wrist, with close-up showing how to align the lights directly on top of one another. Show calm baby and a steady pulse. Close up of one or more readings – one normal and one for a baby with a low SpO2. Visual of pulse tracing,

This probe shows a pulse of XX and an oxygen saturation of XX. This is a normal reading. This baby has a pulse of XX and an oxygen saturation of XX. This baby needs oxygen. (Actual numbers to be inserted here once footage is obtained.) **Trouble Shooting** If you are not getting a good reading or if the baby has a reading below 90% first check the probe placement to be sure it is correct. Check that the heart rate reading on the probe matches the baby's pulse. Look at the baby. Do they have any signs of low oxygen?	pulse number, SpO2 reading. Pulse oximeter readings to be added, based on footage obtained.
Pulse Oximeter – Cleaning Clean the oxygen sensor/probe with alcohol after each use, and plug it back in or check the batteries so it is ready for the next baby.	Health care worker cleaning probe and changing batteries/checking battery level or plugging oximeter in.
Clinical Signs of Low Oxygen If you do not have a pulse oximeter, you can look for clinical signs to see whether a baby needs oxygen: Look for signs that the baby may need help with breathing: • Nasal flaring • Grunting with each breath • Chest in-drawing / retractions • Lethargy – it is difficult to wake the baby • Difficulty with feeding • Breathing less than 20 or more than 60 times a minute • A blue color on the baby's trunk, around the mouth or under the tongue. If the baby has any of these signs they may need oxygen.	Footage of clinical signs, or if not available, animated illustration. The script may need to be modified, based on available footage. "Chest in-drawing" or "chest retraction" – may need to use both terms to ensure clarity.
Respiratory Rate A newborn baby should breathe between 30 and 60 times a minute • Count the baby's breaths for one minute. The baby should not be breathing less than 30 times a minute or more than 60 times a minute.	Counting the respiratory rate by observation – footage from previous videos may be used.
Color A blue color on the trunk, around the mouth, or under the tongue is a sign that the baby has a very low	If available, footage of a cyanosed baby, or an animation or illustration.

oxygen level. Look at the tongue and gums of the baby in natural light. You can compare the color to the color of the mother. A blue color on the hands and feet for newborns is normal, and is not concerning.	Illustrations may be better suited to illustrating difference between peripheral and central cyanosis.
Oxygen / SpO2 Levels The oxygen in a baby's blood increases during the first few minutes after birth. 10 minutes after a baby is born, the oxygen saturation measured on their right wrist should be 85-95%. After the first few hours, an oxygen saturation of less than 90% means that the baby may need oxygen. The oxygen saturation in a healthy baby should be between 90% and 100%.	Simple graphical/written representation of O2 saturation numbers.
Baby Needing Oxygen This baby needs oxygen.	**Footage:** Baby with signs of hypoxia Script to be adjusted based on assessment of actual baby
Using Nasal Prongs The safest way to give oxygen is via nasal prongs. Place prongs just inside nostrils. They should fit about 1mm inside the nostrils for a premature/small baby, and 2mm inside the nostrils for a larger baby. Secure the tubing with tape. You can also attach the tubing using safety pins to a baby hat to protect the baby's skin Make sure the nostrils are clear and are not blocked by mucus. Use normal saline and a bulb syringe to clean them if necessary.	F**ootage:** Illustration of nasal prongs. Health care worker fitting the prongs and applying tape. Footage or illustration of attaching tubing to hat. Footage of using a bulb syringe. Baby's position may depend on clinical scenarios available. If possible show baby supine and in Kangaroo care, or make a note that both are possible options.
Using a Nasal Catheter If nasal prongs are not available, a nasal catheter can be used. • Use a French 8 gauge nasal catheter • Measure from side of nostril to the inner eye brow margin, and mark the tube. • Insert the catheter into one nostril up to your mark. • When you insert the catheter, aim slightly	Use of nasal catheter - show measurement, making of tube, insertion, and securing with tape. Show baby with nasogastric/orogastric tube in place. Orogastric tubes are an alternative option to nasogastric tubes. The script

up and then straight backwards towards the back of the baby's head. • Make sure that you cannot see the tip of the catheter in the mouth below the uvula. • Secure the catheter in place with tape. • Place a nasogastric tube at the same time in the same nostril.	may need to be adjusted if both orogastric and nasogastric tubes are used.
Setting the Oxygen Flow Rate Start 100% oxygen at a flow rate of 0.5-1 liters per minute for both nasal prongs and nasal catheter.	Setting the flow rate on a cylinder, (or on a concentrator/blender.)
Assessing the Baby Who is Receiving Oxygen Once a baby is receiving oxygen, use a pulse oximeter to check whether the baby is getting enough oxygen. Check the oxygen level 15 minutes after you start the oxygen. If you don't have a pulse oximeter, check the baby for signs of respiratory distress. Assess the baby at least twice a day or at every vital signs check: • Check the oxygen saturation • Look for any signs of respiratory distress • Remove, clean, and reinsert the nasal prongs or nasal catheter and check they are positioned correctly. • Check that baby's skin is intact – the nasal prongs can irritate the skin • Do not use any petroleum jelly or lubricants around the nostrils when you are giving oxygen. This can be a fire hazard. • Check all the connections for the oxygen equipment and make sure that oxygen is flowing. • Check the baby for any stomach distention – this might mean that oxygen is getting down into the stomach. Explain to the baby's mother that checking the baby's oxygen levels can help you to see whether the baby is improving. A premature baby receiving oxygen should have a pulse oximetry reading of between 90% and 95% If a premature baby has a pulse oximetry of more than 95%, you should give less oxygen. Do this by decreasing the flow rate. It is safe for the baby to have a level higher than 95% if the baby is not premature or	Checking the baby – looking at skin, checking/cleaning prongs, assessing for abdominal distention. Checking equipment. Illustration of correct pulse oximetry for a baby receiving oxygen.

if the baby is breathing room air	
If the baby is not improving If the baby is not getting better: • Check for leaks in the oxygen equipment • Check that oxygen is flowing from the cylinder or concentrator. You can put the end of the prongs or catheter in water to watch for bubbles • Check the oxygen flow rate • Check that the nasal prongs or catheter are still in place • Check that the probe on a pulse oximeter is correctly placed and is reading accurately • Check for any airway obstruction in the baby. Be sure their nose is not blocked – suction mucus if needed • If needed you can increase the oxygen flow up to 2 liters per minute	Animated list of these points or actual footage.
When to Refer the Baby If you have tried all these steps and the baby is not getting better, they may need more advanced care. Refer the baby to a hospital that can provide this care if you can. If you are able to refer a baby who needs more advanced are, make sure you know who to call and where to send the baby.	Animated shot of ambulance referral as shown in other GHMP videos.
Stopping Oxygen If the baby does not have any clinical signs of respiratory distress, and their oxygen saturation has been stable and over 90%, try stopping the oxygen for few minutes every 12-24 hours. This baby is stable. They do not have any signs of respiratory distress and their oxygen saturation has been above 90% for 24 hours. The oxygen can be discontinued to see if they no longer need it. Watch the baby carefully for at least 30 minutes. Continue to measure the baby's pulse oxygen level with the pulse oximeter. Make sure that it 2does not drop below 90%. Keep checking the baby for any signs of respiratory distress. If the baby's oxygen levels drop below 90%, or they have any signs of respiratory distress, restart the oxygen.	Baby having oxygen discontinued WHO states that if oxygen saturation drops below 80% when trying to wean, oxygen should be restarted. 24 hours with an Sp02 greater than 90% is specified here for the purposes of a video example.

Discharging the Baby The baby can be discharged if: • S/he has a stable oxygen saturation of at least 90% while breathing room air (not receiving oxygen) and no signs of respiratory distress for at least 24 hours	
Key Points/Review Remember: • Measure oxygenation using a pulse oximeter, or assess by looking for clinical signs of respiratory distress. • Provide supplemental oxygen if a baby has an oxygen saturation of less than 90% or has signs of respiratory distress. • Give oxygen by nasal prongs. Use a nasal catheter if prongs are not available. • Aim for an oxygen saturation of 90%-95%. If the oxygen saturation is more than 95%, decrease or discontinue the flow rate of the oxygen. • Continue to monitor the baby • Give oxygen until the baby is able to keep their oxygen level above 90% while breathing room air. • If the baby is not getting better, be ready to refer them if there is a hospital that can provide more advanced care.	Checklist with still shots of each step

SCRIPT 2: OXYGEN SAFETY	
Script	**Footage and Notes**
Some babies with respiratory distress need extra oxygen. This video reviews how to store and use oxygen safely in your health center.	
If your health center has oxygen: ○ Store tanks and cylinders upright and make sure they cannot tip over and hurt someone ○ Store empty and full cylinders separately and label them clearly ○ Protect cylinders from very hot or cold temperatures and direct sunlight ○ Keep cylinders dry to prevent rusting ○ Do not allow anyone to smoke or to have any kind of flame near the oxygen supply. ○ Make sure you have no smoking signs near the oxygen supply and near the baby's bed.	**Footage:** Show oxygen tanks stored and secured correctly. Labeled area for empty and full cylinders. No smoking signs over the bed next to the oxygen. May depend on how many O2 tanks a site has. May need to take / make signage in English and in local language
Make sure that your oxygen supply is working correctly. Use a checklist at least twice a day: ○ Make sure that the oxygen is available at all times ○ Check that there is enough oxygen in the tank and that the supply is working ○ If you are using an oxygen cylinder check the gauge by opening the valve. ○ If your cylinder does not have a gauge, turn the oxygen on and listen for a "hissing" sound. This will tell you that oxygen is flowing. ○ If the needle on the cylinder is near empty or in the red area of the gauge – get a new cylinder. This cylinder is empty and needs to be replaced. ○ If you are using an oxygen concentrator, be sure that the electric supply is working and that you have a backup source of power available such as a generator.	**Footage:** Show how to read the gauge on the oxygen cylinder. Show needle moving to full, and a cylinder where the needle is close to empty. WHO Manual on Oxygen Therapy, 2016 has more information about maintenance for an oxygen concentrator, including cleaning the particulate filter, and calibration of the concentrator if needed.
Make sure that your oxygen supplies are ready. Check them each at least twice a day You will need: ○ Your oxygen source ○ Oxygen tubing ○ Nasal prongs or a nasal catheter for babies who need ongoing oxygen ○ Tape to secure the prongs	

○ A nasogastric tube if you are using a nasal catheter ○ A pulse oximeter if available with a probe that will fit a small baby. Clean the oxygen sensor/probe after each use with alcohol. Plug it back in or check the batteries after each use so that it is ready for the next baby.	

Appendix II

IRB Determination: Not Research

The UNIVERSITY of VERMONT
Committees on Human Subjects
Serving the University of Vermont
and the UVM Medical Center

RESEARCH PROTECTIONS OFFICE
213 Waterman Building
85 South Prospect Street
Burlington, Vermont 05405
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Certification

Not Research Determination

TO: Martha Whitfield
FROM: Sarah Wright, Research Review Analyst
DATE OF CERTIFICATION: 29-Apr-2016
SUBJECT: CHRMS: 16-598
Best Practices for Providing Oxygen to Premature Infants in Low-Resource Settings

The IRB has determined that this project does not require IRB review because it does not meet the definition of a "research" activity under the regulatory definition adopted by UVM. According to 45 CFR 46.102(d), the definition of "research" is "a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge."

Projects that are not a systematic study or are not intended to contribute to generalizable knowledge, e.g. quality assurance, quality improvement, program evaluation, or public health practice, do not require IRB review.

Thank you for contacting the Committee to make this determination.

cc: Hendrika Maltby

Appendix III

Expert Feedback Comments

This table summarizes feedback on specific questions related to the script, as provided by Danielle Ehret, MD, MPH.

Guidance Sought	**Expert Feedback**
The extent of background information that should be provided during the video introduction, given time limitations.	Provide simple information using practice guidelines and recommendations to guide the content. Aim for maximum educational impact. Clinical judgment will enter into most scenarios in which an infant requires supplemental oxygen. The nuances of clinical judgment can be difficult to convey in a video format however, and are by nature specific to individual circumstances. Supplemental oxygen is helpful to support oxygenation, but will not be sufficient for the infant that needs assistance with ventilation (PPV with bag-mask, CPAP, mechanical ventilation) or for an infant with cyanotic congenital heart disease.
Whether a pre-ductal oxygen measurement is necessary in neonates, given that obtaining pre- and post-ductal measurements could potentially help to identify cardiac issues in a newborn baby.	While cardiology referrals may not be available in many settings, it is simple to instruct health care providers to use a baby's right wrist for pulse oximetry whenever possible. Instructions should specify the use of the right wrist where possible. If the right hand or arm is used for an IV it may not be possible to adhere to this recommendation in some cases.
Recommended frequency of assessments when starting oxygen, and when providing ongoing monitoring while a baby is receiving oxygen.	In many settings, one pulse oximeter may be shared amongst several patients. Recommendation for re-testing the SpO2 at 15 minutes, while acknowledging that, for infants on oxygen, routine assessment may include pulse oximetry testing once or twice per day only.
Clinical signs of hypoxia that should be included in the section on assessing a baby when pulse oximetry is not available.	Although central cyanosis is a late sign of low oxygen in a baby, it is also specific, and a useful sign if pulse oximetry is not available.
Recommended technique for counting a respiratory rate.	Respiratory rate should be counted by observation for a full minute. While listening with a stethoscope

	is also an appropriate way to count a respiratory rate, in a small baby a cold stethoscope can cause tachypnea. 30-60 BPM is suggested as a reference .
Optimum positioning of a baby receiving oxygen, and whether the baby should remain on the mother's chest for warmth, or be positioned supine or prone.	Kangaroo care - with the baby positioned on the mother's chest - recommended for all premature or low birth weight infants, and for those babies that need additional warmth. While prone positioning is sometimes used in the NICU, the supine position is recommended for video purposes as the best for continued assessment of respiratory status. If feasible, include footage of babies in both supine and kangaroo positions receiving oxygen.
The acceptability of using a nasal catheter without a nasogastric tube, if this is the only available option for oxygen delivery.	Nasogastric tubes may not always be placed in practice; however given guideline recommendations for their use, these instructions should be included in the video. An orogastric tube could be used in place of a nasogastric tube if desired.
Clarification on desired SaO2 levels during assessment and when weaning oxygen.	Detailed and differing numerical values for potential SaO2 levels may be confusing. Pre-ductal SaO2 should be at 85-95% by 10 minutes after birth. 90% can be used as a cut-off for the consideration of supplementary oxygen in babies more than a few hours old. SaO2 levels when weaning require clinical judgment. Stability before weaning needs to take into account the reason that the infant needs oxygen. An infant with transient tachypnea of the newborn, that will likely get better in hours, versus pneumonia or prematurity that will take days should be handled differently. A detailed discussion of possible scenarios for oxygen levels during weaning is likely beyond the scope of a short video.
Clarification of Sp02 reference range for premature or low birth-weight infants receiving oxygen.	Sp02 levels are highly debated. Some ranges can go down to 87% and some up to 97%. A range of 90-95% can be considered safe and realistic, especially

	given that babies are unlikely to have continuous monitoring of oxygen levels, and associated adjustments to their oxygen dosing.

Appendix IV

Suitability Assessment of Materials, including Readability Analysis

Suitability Assessment of Materials (SAM)	**Points:** **2 superior** **1 adequate** **0 not suitable** **N/A**
1. Content a. Purpose is evident b. Content about behaviors c. Scope is limited d. Summary or review included	a. **2 points.** Purpose is explicitly stated in introduction b. **2 points**. Thrust of the material is application of knowledge/skills aimed at reader behavior c. **1 points.** Scope is limited to essential information directly related to the purpose. (2) Key points can be learned in time allowed. (1). d. **1 point**. Summary is included – adequate – could use different words and examples?
2. Literacy demand a. Reading grade level – Fry Formula b. Writing style, active voice c. Vocabulary uses common words d. Context is given first e. Learning aids via "road signs"	This is assessed for the script only – which will be narrated in the final video a. **1 point.** Grade 6-8 for most samples. Depending on sample taken ranges from 5-9, however technical and subject-specific words contribute to higher readability scores. Almost all words identified as "harder" are directly related to the subject of the video eg: oxygen, pulse oximeter, saturation. b. **2 points**. Mostly active/conversational voice. Simple sentences predominate. Some sentences have embedded information. c. **1 point.** Common words are used where possible. Technical words are explained. Need to balance explanation with brevity. d. **2 points.** Consistently provides context before new information is presented. e. **2 points.** Advance organizers precede each topic. (These are included in the script as it is – will depend on format of video).
3. Graphics a. Cover graphic shows	N/A

purpose b. Type of graphics c. Relevance of illustrations d. List, tables, etc. explained e. Captions used for graphics	
4. Layout and Typography a. Layout factors b. Typography c. Subheads (chunking) used	N/A
5. Learning Stimulation, Motivation a. Interaction used b. Behaviors are modeled and specific c. Motivation – self-efficacy	a. **0 points.** No interactive learning stimulation provided b. **2 points.** Behaviors are described and specific. Instruction models specific behaviors and skills c. **2 points.** The information is divided up into different skills – including assessment, decision making and technical skills
6. Cultural appropriateness a. Match in logic, language, experience b. Cultural image and examples	a. **2 points**. Effort made through research and expert consultations to match the technology available with the scripted instructions b. **2 points.** Images and examples will be designed to present low-resource settings in a culturally sensitive manner.
Total SAM Score: 22 **Total possible Score: 28** **Percent Score: 78%**	**70-100 % - superior material** **40-69 % - adequate material** **0-39% not suitable material**

Adapted from the Suitability Assessment of Materials (SAM) tool. For details on scoring specifics and the SAM tool see Doak, Doak and Root (1996)