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Accuracy of RN Visual Quantification of Emesis Volumes in the Neonatal Intensive Care Unit

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By

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DNP Scholarly Project Committee

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Submitted in partial fulfillment of the Requirements for the degree of

Doctor of Nursing Practice

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Approval of Project Defense

Stephen Stoever has successfully defended and made the necessary modifications to the text of this Final Scholarly Project for the DNP this Fall, 2020 semester

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Dedication

This manuscript is dedicated to the countless friends and family who have walked with me on this journey. What began as a desire to add to my knowledge and understanding of advanced practice nursing has led me down this road to achieving my Doctor of Nursing Practice degree. Throughout this process, there have been many challenges, including loss, hardship, and pain. But those friends and family lifted me up and carried me through some of the darkest times of my life, while continuing on this educational journey.

There have been many nights where I wanted to give up, but I pressed on. I could not have done this without my parents, brothers and sisters' encouragement.

To my best friend and the SpongeBob to my Squidward, Javier: who pushed me every day to pursue my dreams and worked alongside me to make them happen despite the challenges that came my way. I love you, "luce dei miei occhi." To Rocco and Rosie, my furry little cheerleaders, who made me smile and press on towards a better, brighter future. I love you!

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Abstract

An important component of nursing assessment of feeding tolerance in the neonatal intensive care unit (NICU) for both low-risk and high-risk babies, is the quantification of emesis volumes. While some nurses attempt to weigh the items saturated in emesis in order to quantify volume loss (QEV), there is no or limited consistency in this practice across nurses in this unit. Rather, volumes are "best-guessed" or estimated (EEV) and reported to the practitioner for decision-making. Often feed advances are paused or limited due to perceived feeding intolerance connected to emesis events in neonates.

For this project, 158 NICU nurses at a large metropolitan children's hospital in New York City were given a survey consisting of ten images of simulated emesis volumes on standard hospital linens and asked to estimate the emesis volumes (Appendix B). Nurses were also surveyed on demographics, their attitudes and beliefs related to emesis in neonates, and personal practices regarding this issue.

Compiled data results revealed that nurses were able to correctly estimate the simulated emesis volume presented to them an average of 34.5% of the time, regardless of educational level, years of experience, or presence of certification in their specialty. It is clear that visual quantification of emesis volumes is a highly inaccurate method to assess feeding tolerance and guide feed advancement in the NICU. Further research is needed on how these methods affect time to full feedings and overall NICU length of stay.

Keywords – neonatal, infant, emesis, estimate, quantify, quantification, neonatal ICU, preterm, NICU, nursing

Background

This doctoral-level quality improvement project was initially developed in the Fall of 2019 and assigned the working title "Accuracy of RN Visual Quantification of Emesis Volumes in the Neonatal Intensive Care Unit" which has been shortened to better reflect the aim of the project as a quality improvement project. The following sections describe the terms used in this project, a description of the project, and stated goals and objectives.

Definition of terms

Common terms utilized throughout this project include the following:

1. *Neonatal Intensive Care Unit:* The setting of this project is a neonatal intensive care unit within a children's hospital, in which patients from birth to age 1 year are cared for by specially trained nurses, critical care neonatologists, advanced practice nurses, and other multidisciplinary team members.
2. *Neonate:* Refers to a patient within the first 28 days of life
3. *Infant:* Refers to a patient after 28 days of life through one year old.
4. *Preterm neonate:* Neonates born prior to 37 weeks completed gestation. These have been further categorized by the World Health Organization to refer to those born before 28 weeks gestation as extremely preterm, from 28 weeks completed gestation through 31 6/7 weeks as very preterm, and those neonates from 32 weeks through 36 6/7 weeks completed gestation as moderate, or late-preterm infants (Preterm birth, 2018).
5. *Term neonate:* Neonates born at or after 37 weeks completed gestation. This definition has been further expanded by the American College of Obstetrics & Gynecology to categorize births from 37 0/7-38 6/7 weeks as early term, those from

39-40 6/7 weeks as full term, 41-41 6/7 as late term, and those after these gestations as post term (Spong, 2013).

6. *Emesis:* Can be used interchangeably as a verb to describe the act of vomiting or regurgitating stomach contents, or a noun, to describe the contents themselves.
7. *Estimated Emesis Volume (EEV):* Emesis volumes measured by estimation techniques.
8. *Quantified Emesis Volume (QEV):* Emesis volumes measured using standardized or calibrated devices.

Description of the project

This quality-improvement project consists of a quantitative, cross-sectional descriptive survey of nurses practicing within the neonatal intensive care unit setting. Presented with high-resolution images of simulated emesis volumes placed on various commonly used hospital linen items, nurses were tasked with visually estimating the volume of emesis on twelve items. Additional questions regarding demographic information and attitudes and beliefs surrounding emesis volumes in neonates and infants were also applied to the sample.

Once data collection was complete, results were further stratified based on years of experience and educational level to glean further information as to their effect on accuracy of volume estimation, if any. Following data compilation, stakeholders involved in the project were presented with the results to provide insight for future project direction and practice improvement across all disciplines.

Purpose of the project

This primary purpose of this project was to determine the overall accuracy of nurses' estimation of emesis volumes in the neonatal intensive care setting. Other purposes of this project include shedding light on the inaccuracies of visual estimation of most fluid volumes, guiding current practice to methods that provide far more accurate and reliable information in the development of appropriate patient care plans, and decreasing length of stay, thereby increasing family/caregiver satisfaction. Current scientific literature on this subject remains limited, with only a few neonatal-specific studies existing from the past several decades.

Goals and objectives

1. *Identify and establish buy-in from all key stakeholders potentially involved in the project.*
2. *Identify a sample of registered nurses working in the NICU and its satellites within a large metropolitan hospital system in New York City.*
3. *Collect demographics of nurse sample group, consisting of age, training, experience, and attitudes regarding estimation of emesis volumes in neonates and infants.*
4. *Create a mobile survey platform to assess various simulated emesis volumes on standard hospital substrates and administer a survey on their visual estimates for each volume to assess accuracy rates.*
5. *Assemble a dataset of all collected answers/data and compile a visual report to meaningfully represent this data.*
6. *Present results to key stakeholders, including nurses who were part of sample.*
7. *Review completed surveys with key stakeholders and identify areas of additional training or education needed, as well as areas of needed additional research.*

A nurse leader mentor was identified, as was a neonatology physician advisor, who both willingly engaged to assist with this project. Following several months of delays due to the 2020 global SARS-CoV-2 pandemic, the organizational Center for Professional Nursing Practice (CPNP) committee approved this project proposal for implementation, as well as granting an institutional review board (IRB) exemption.

Significance of the project

A well-known issue within the walls of any NICU, emesis occurrence in neonatal and infant patients is an important consideration in feeding plan advancement on a daily basis. With the risk of potentially catastrophic illnesses, such as necrotizing enterocolitis (directly related to early gestational age, susceptibility to intestinal wall penetration, and bacterial translocation), careful decision-making in the NICU is often centered on signs of feeding intolerance. While neonates of all gestational and chronological ages experience emesis events at some point in their NICU stay, there exists great variability in how the amount, and therefore the significance, of the event is determined. The medical team in the NICU uses emesis, along with other assessment data such as abdominal exam findings to guide feeding advancements, increase caloric intake, and promote growth in at-risk neonates and infants.

A commonly observed problem in obtaining the necessary information for advancing neonatal feeds is that the practices of quantifying emesis vary greatly among nurses. What might appear as a small, insignificant emesis event to one nurse, may appear as a larger volume and therefore more serious event requiring evaluation and possible alteration of feeding plans. The majority of nurses in the NICU use visual estimation (EEV) as a method of emesis measurement, as opposed to a standard method, such as a scale, to weigh the saturated items (QEV). This

results in great variability in assessed volumes, and unduly affects decision-making when based on inaccurate information.

When a literature review was performed as part of this project, it was noted that across multiple specialties including NICU, nurses and other providers were found to be routinely inaccurate in visually estimating volumes of various fluids, which leads one to believe that this issue extends far and wide outside of the neonatal intensive care setting.

Literature Review

When examining the scientific literature on this topic, multiple databases were utilized via the Seton Hall University Library system, as well as Google Scholar, linked directly with Seton Hall Library access. These databases included ScienceDirect, PubMed, Ovid, and CINAHL. When necessary, manuscripts and articles were procured though the library ILLiad system. The timeframe for publication dates was initially limited to 5 years, then expanded to all available literature regardless of date once recent publications were determined to be limited. Search terms used included “neonatal”, “infant”, “emesis”, “estimate”, “quantify”, “quantification”, “neonatal ICU”, “preterm”, “NICU”, and “nursing.”

Studies chosen for review included quantitative research papers and peer reviewed journal articles. Initially, due to few available papers involving neonates and infants, the search was broadened to include papers from the adult population. After final review, ten papers were selected for inclusion in this project paper. Only three papers addressed nurses and other caregivers visually estimating simulated neonatal emesis volumes. One study found that very few neonatal emesis volumes were correctly assessed (M=2.63), that nursing experience had no effect on accuracy, and repeated tests with the same volumes produced different estimates (Craft & Moss, 1996). Additionally, when subjects were given a standard frame of reference volume of

50ml, they were able to assess simulated emesis volumes with a 20% higher accuracy rate (Craft & Moss, 1996).

A single-blinded survey done of 271 parents, caregivers, and 133 healthcare workers using simulated emesis volumes on hospital pajamas found that health care workers underestimated the larger of the simulated volumes by 81.9% and 85.8% ($p < 0.001$ and 0.002, respectively) and overestimated the smaller volumes by 150.4% and 145.1% ($p < 0.001$) (Pitre & Acker, 2013). Parents and home caregivers overestimated all volumes presented to them, ranging from 130.4%-275.7% (Pitre & Acker, 2013). Additional data demonstrated that experience level or area of expertise (physician, nurse, ICU, nursery, etc) made clinicians more accurate at estimating volumes (Pitre & Acker, 2013).

A prospective, correlational study by Moore & Pickler (2013) utilized a combination of abdominal assessment photos and photos of simulated emesis volumes with 46 neonatal ICU nurses to assess accuracy. Again, wide variation in values was assessed, with years of clinical experience having no bearing on accuracy results. Correct results varied from 15-24% for emesis estimates, and abdominal exam assessments were widely variable, even on the same patient photographed from an alternate angle (Moore, et al., 2013). The researchers pointed to the study as evidence for the need for "NICU educators…to develop policies that support standardized interpretation and recording visual assessments" (Moore et al., 2013, p. 187).

When the literature review was broadened to include areas outside neonatology and pediatrics, evidence was discovered for the inaccuracies of visual volume estimation in a variety of hospital and emergency settings. Patton, et al, (2000) found that EMS personnel assessed blood volume loss within 20% of the correct value less than 8% of the time, 19% within 50% of the correct volume ($p < 0.05$) with no difference noted based on experience level.

Several studies focused on the peripartum setting. Glover (2003) found that "midwives and other health professionals underestimate blood loss at delivery by 30-50%" in an Australian study using 5 physicians, 21 midwives, and one midwifery student. A prospective cohort clinical trial involving 242 patients by Saoud, et al., (2019) using a blood collection and measurement device showed that the device provided more accurate predictions of post-caesarean delta hemoglobin levels than visual estimates ($p < 0.01$). Pranal, et al, (2017) in a simulated postpartum hemorrhage study using 463 French midwifery students and 578 practicing midwives demonstrated that medical providers were only able to accurately assess blood volume loss 34.1% of the time, with students consistently underestimating losses at all volumes ($p < 0.05$).

Lilley, et al., (2014) using a gravimetric blood estimation tool, showed a "mean percentage error of 4.0 +/- 2.7% compared to visually estimated blood volume with a mean percentage error of 34.7 +/- 32.1%"

A prospective study including 55 surgical cases by Budair, et al., (2016) examined the accuracy of visual estimation of surgical blood loss during hip fracture surgery. On observing 8 orthopedic surgeons and 6 anesthesiologists, it was noted that both surgeons and anesthesiologists vastly underestimated actual blood loss both pre and post-operatively ($p < 0.001$) (Budair et al., 2017).

While scant literature exists directly observing the accuracy of RN quantification of emesis volumes in the neonatal intensive care unit, multiple studies of various disciplines have demonstrated the inaccuracy of healthcare providers visual estimation of blood and emesis volumes. This data continues to be statistically valid in spite of years of clinical experience, discipline, training, and attempts at targeted educational programs. It is critical to enlarge the

research surrounding the specific patient population of neonates in order to shed light on the inaccurate practice of visual quantification of emesis volumes in the NICU.

Project Methodology

Using a customized survey framework from Google Forms, a survey link was sent via email to a convenience sample of 158 nurses employed within the quaternary main NICU and its subunits at our large metropolitan hospital in New York City. This quantitative, cross-sectional, descriptive survey was divided into three sections, the first consisting of five questions on demographics such as years of experience, education level, and whether or not the nurse possessed certification in their area of specialty. The second section consisted of six questions on attitudes and beliefs regarding neonatal emesis, including how the nurse might assign significance to different amounts of emesis following a feeding or a particular gestational age or abdominal exam. The final section of survey questions was made up of ten images of simulated emesis volumes on standard hospital linen provided to the NICU, and the nurse was asked to choose an amount of estimated emesis volume present in that simulated image from a set of multiple-choice answers.

To create the simulated images, standard hospital washcloths, receiving blankets, newborn snap-type shirts, blue absorbent underpads, and white dry wipes were used as the substrate. Standard hospital infant formula was either drawn up in a syringe to the desired measurement, and splashed onto the substrate, or for larger volumes, a premeasured volume was placed in a paper cup and poured onto the substrate to simulate emesis. A high-resolution photograph was taken immediately after the liquid was placed on the substrate using an iPhone XS, and each image was adjusted using the built-in photo editing features of the phone to

maximize visual contrast between the substrate and the formula before being added to the survey.

These simulated images consisted of formula volumes ranging from 2ml to 50ml, across a variety of substrates as mentioned previously, for example: blue underpads and a hospital baby shirt. Once the survey design was completed, it was sent to nursing leadership, who forwarded the link to the various nursing staffs within the NICU and its sub-units. Nurses were informed of the survey and its purpose during staff huddles at the beginning of each shift and in staff meetings. Once 4 weeks had elapsed following survey release, it was closed to responses.

Prior to the development and subsequent release of the survey, additional work was also completed on a thorough literature review using multiple cross-discipline database searches, project budget planning, marketing planning, and risk analysis using the situation, weaknesses, opportunities, and threats assessment method.

Theoretical Framework

A theoretical framework is critical to the logic development and implementation of a quality improvement project. This framework serves as the underpinnings of the project, and all aspects of the project are approached using the particular lens of whatever theory was utilized to guide it. For this project, Orlando's Nursing Process Discipline Theory was chosen.

This theory is built on several concepts surrounding the patient who is undergoing health disturbance and is reaching out for help. The nurse is engaged via this theory as the entity who receives and recognizes this call for help and is responsible for interpreting it in order to meet the patient's particular need to return to health (Petiprin, 2016). Laid out in chronological order of occurrence, these concepts consist of "function of professional nursing, presenting behavior, immediate reaction, nursing process discipline, and improvement" (Petiprin, 2016).

When explored in the context of this quality improvement project, the NICU nurse serves as the professional nurse who is tasked with caring for his or her at-risk patient. When the patient presents behavior, in this case emesis, the nurse generates an immediate reaction. This reaction then sets in motion a series of diagnostic and assessing behaviors steeped in the nurse's own belief system and may not be congruent with the actual significance of the behavior the patient is presenting. "An observation shared and explored with the patient is immediately useful in ascertaining and meeting his or her need, or finding out if he or she has no needs at that time" (Petiprin, 2016). It is assumed that the nurse compares their reaction with what is actually occurring in order to ensure that the reaction is correct. In the case of this study, the nurse may be relying on an inaccurate method of exploring the significance of an emesis episode, leading to negative patient effects and delay in return to health.

The improvement concept speaks here to the patient's return to a domain of healthy behaviors. The nurse continues approaching each patient interaction and reach for help as an opportunity to use their own reaction to explore the true significance and nature of the patient's perceived distress (Petiprin, 2016).

Risk Analysis

A necessary step in preparing a project for development and implementation is the analysis of strengths, weaknesses, opportunities, and threats that may come into play during the project. For this project, strengths primarily consisted of a single, large unit in which to perform the study, a general familiarity of nurses with ongoing research, and close collaborative relationships with a majority of the nurse stakeholders.

Identified weaknesses were linked primarily to a general high acuity which may prevent participation, as well as a particularly entrenched feeding culture among nurses on the unit. Other

items identified were lack of access to necessary supplies, as well as a large number of nurses to reach out to on multiple shifts.

External opportunities primarily revolved around a renewed national healthcare focus on decreasing length of stay and reducing hospital-based problems such as infection. Another identified opportunity was increasing nursing education through new available research findings.

While not numerous, no less important external threats consisted of lack of visibility, lack of needed supplies, and a shifting focus from formula feeds to breastmilk-forward feedings which may prove difficult to access for testing.

When examining individual identified risks using a risk management matrix (Baker, Baker, & Campbell, 2003, p. 83), it is necessary to evaluate each in light of their projected impact on the presented quality improvement project. For purposes of this project, the five most important risks identified in the matrix were further evaluated and potential solutions and stop-gap measures were proposed to mitigate risks to project success.

The first risk identified, and also most impactful was the potential for lack of nurses' participation in the project due to patient care responsibilities. While working in a large metropolitan level VI NICU, nurses are often found caring for highly acute and work-intensive patients on all shifts. This may result in nurses being unable to be away from their patients and responsibilities long enough for the project surveys to take place. To reduce the impact of this risk, identified solutions included close collaboration with nursing leadership to arrange for coverage of the nurses' assignment while he or she participates in the survey, as well as scheduling surveys outside clinical time. Other potential solutions including interviewing nurses regarding the optimal time during their shift to participate, as well as creating a mobile study platform to bring it to the nursing care pod, rather than requiring the nurse to go off-unit.

Ultimately, due to unique challenges surrounding the SARS-CoV-2 pandemic in New York City, an online survey was ultimately developed to minimize infection risk, and also allowed the nurses to complete at their own pace.

The second risk identified was the lack of available current research specific to the visual quantification of neonatal and infant emesis volumes. While a few legacy studies from the 1990s (Craft & Moss, 1996), and early/mid 2000s (Pitre & Acker, 2013) exist, they are not recent or numerous enough to meaningfully impact new quality improvement (QI) efforts. To mitigate this, additional literature review focusing on the adult arena was performed. Adult studies regarding volume estimation for patients with postpartum hemorrhage, trauma-related blood loss, and surgical blood loss were located as part of the literature review. These reports proved useful in not only driving focus for this QI project, but also allowing for this new project to add to the body of research.

The third risk noted was the potential for interruptions in, or lack of access to appropriate study substances, in this case, donor breastmilk. In the clinical setting, neonates and infants consume both breastmilk and infant formula as part of their diets, and thus their emesis consists of various fluid densities. While the impact of fluid densities on visual estimation of emesis volumes is not well known (Dowling, Madigan, & Siripul, 2004), having access to real-life test substances is critical for conducting this QI project. Interventions to prevent this problem were identified as collaborating closely with on-unit lactation consultants, as well as nurses accessing the donor milk bank to identify and divert expired donor milk lots for use in the QI project. Also, by utilizing current relationships with nursing attendants in charge of formula stocks to procure expired formula bottles for survey testing will help mitigate lack of supply once the project

begins. Ultimately, the decision was made to use only commercially manufactured formula, to avoid IRB approval issues, and potential exposure to biological material.

The fourth risk identified was the potential for difficulty in accessing a large enough sample size of nurses. The NICU at the study hospital spans three floors and three separate units, as well as two shifts. This configuration could result in a sample size that may not be adequate for project impact. To reduce this risk, the development of an online survey permitted access to the project questions remotely, and at the nurses' convenience.

The final risk considered was lack of project visibility when implemented in a busy NICU that already has many ongoing clinical research and QI projects at any given time. Through use of a multimodal approach consisting of information sessions during nursing shift change huddles, one on one interactions, and emails, visibility did not prove to be an issue. Close relationships with both nursing and medical leadership were also leveraged to promote awareness and increase participant buy-in from key nursing stakeholders.

Implementation Timeline

This project was implemented in several phases, the first of which included identification of the project question, project framework, budget, marketing plan, and development of an online survey. The survey dissemination and data collection phase began in the summer of 2020 after several months of delays due to the novel SARS-CoV-2 pandemic. This global health pandemic resulted in diversion of critical hospital resources, as well as a complete halt in research projects and student clinical activities. Once the infection curve flattened in the New York City area in early summer, the organization's Center for Professional Nursing Practice granted resumption of graduate student projects.

Survey data collection was completed 30 days after it was disseminated to the NICU and its subunits, and by the beginning of August 2020, the resulting data was compiled into meaningful forms in preparation for submission as part of the requirements for doctoral degree consideration.

Budget

A project budget represents an estimate of expenses to be incurred during the development and implementation of the project proposal.

Expenses related to personnel and labor for this project were zero due to the entirety of labor being performed by the student researcher. In repeating this project, labor costs would need to be considered as a valid expense factor. Variation in cost estimates may occur in different regions based on salary and discipline of the data collector, such as a registered nurse rather than a nurse practitioner. It was estimated at the start of the project and confirmed at completion that a total of 50 hours would be needed for form development, survey rollout, data collection, compilation and dissemination of findings to key stakeholders. Using local salary metrics for a neonatal nurse practitioner in the New York City area, this cost would be estimated at a total of $3325.

Supplies needed for this project were originally expected to consist primarily of standard office supplies such as ink, toner, paper, and poster printing costs. However, due to the project survey transitioning to web-based delivery, these costs were not encountered. Standard hospital receiving blankets and expired standard infant formula from NICU floor stock were projected to be used to complete the project. Formula was to be drawn up and measured using the same 60cc standard feeding syringe, which was to be cleaned and used throughout the data collection

period. Aside from an additional medication cup and additional syringe sizes used for increased accuracy, this budget projection was found to be consistent.

As this project was designed to be performed within a hospital NICU, marketing or advertising costs were not expected to occur outside those related to separately budgeted office supplies and printing costs. All advertising done in relation to the project was performed via nursing huddles, staff meetings, in-person discussions, and over email listservs. It is expected that in repeating this project in another NICU, the budgeted expenses would be similar to this project.

The potential benefits received from this project include increased awareness and education of the nursing staff on using visual quantification as a method of emesis measurement in newborns and infants. Another potential benefit might include less disruption in feeding protocol advancements, thereby reducing both time to full feeds and length of stay. These effects would require a study of much larger scope; however, one may deduce the effects of more accurate emesis measurement using scales and standardized measurement practices. This project lays the groundwork for additional research focused on decreasing time to full feeds, decreased central line dwell days, and an associated decrease central line infection rates.

Marketing Plan

In developing a marketing plan for this project, it was critical to identify key stakeholders and marketing targets, who would be involved in the project in some way. This could be to review and approve the proposal, provide funding, assist with implementation, or to simply be involved in the project as research subjects. For this particular project, the key stakeholders to which the proposal must be marketed to include the Center for Professional Nursing Practice

(CPNP) at the study organization, who oversees and approves all official nurse-led projects in the hospital system.

Other stakeholders included the Advanced Practice Nurse Director, who is an immediate supervisor, as well as the nursing supervisors on the units implementing this project. Another group consisted of a DNP program coordinator, as well as an identified project mentor. The nurses who were involved in the program were also considered critical marketing targets.

The project's focus is one with which each nurse in the neonatal ICU engages on a daily basis in patient care. In this respect, it was critical to actively engage the nurses as well as provide clear information on how this project stood to benefit their patient population. When engaging nursing and executive leadership, it was critical to emphasize the minimal financial costs and potential impact to cost-savings in the NICU. While cost savings is not the primary focus of this study, it is a potential result of decreased time to full feeds in patients and reduced length of stay.

This project was submitted for institutional review board exemption via the CPNP and received sign-off from nursing leadership and unit-based nursing education leaders. This was achieved using email communication, team huddles, information board postings, and one-on-one informational sessions. This project was also submitted and approved for future poster presentation at a national neonatal nursing conference, which provides further evidence to the value of this project.

Once approved for an official start date for the project to begin, an additional round of information sessions and team-based discussions was implemented. Findings from ongoing and already completed literature review were shared with the stakeholders/marketing targets in order to increase knowledge base, and to augment buy-in as the potential benefits of this study are

understood. Short and long-term goals of the project were reiterated and a timeline for project implementation and findings dissemination was shared.

Once the project is complete and data and findings are compiled, it will be prepared into a manuscript and poster presentation and marketed and submitted to neonatal nursing journals for publication, as well as national conferences for knowledge dissemination.

Project Outcomes

A total of 158 completed surveys were returned, which represented a 58.7% response rate across all the NICU subunits. Demographic data revealed that of 158 nurses surveyed, 28% possessed 2-5 years of NICU experience, followed by 25.5% with greater than 20 years, and 22.9% with 6-10 years of experience. When asked about their level of education, 58.6% of nurses possessed their bachelor's degree, 38.2% possessed a master's degree, and 3.2% had earned a doctoral degree. 93.6% of those surveyed reported receiving the majority of their education in the United States, and 50.3% reported a desire to continue their education to the master's or doctoral level. When questioned regarding whether or not they had attained certification in their specialty through a national credentialing organization, 55.4% reported that they possessed active certification.

The second portion of the survey focused on attitudes and beliefs surrounding emesis events in the neonatal and infant population, as well as personal practices and observations. When asked whether they would be more likely to suspect feeding intolerance in a preterm neonate as compared to a term neonate both experiencing the same degree of emesis events, 79% reported yes they would. 63.4% of nurses reported visually estimate emesis volumes (EEV) on a regular basis, followed by 24.8% who reported using a scale to weigh the soiled item (QEV).

The remaining 11.8% cited a combination of methods, or used another means of describing emesis events, such as small, medium, large, etc.

When asked for their opinion on which method of measurement they believed to be the most accurate, 91.7% of nurses chose the scale method as the most accurate, followed by 5.1% who chose estimation as their most accurate method. The remaining 3.2% listed other opinions, such as there being no accurate way to measure emesis in this population or required multiple methods to collect measurements. Nurses were also asked to report which methods of measurement they felt were the primary method used in their NICU, and 96.8% of surveyed nurses answered that the nurses on their particular subunit use visual estimation as the primary method of measurement.

When asked to choose from commonly utilized assessment tools or findings they use to assess feeding tolerance, nurses reported checking residuals (66.9%), abdominal exam findings (96.8%), X-ray findings (58.6%), emesis occurrences (84.1%), emesis volumes (77.7%), or history of stooling occurrences (74.5%) to guide practice.

When questioned on findings which would cause them concern in any baby experiencing emesis events, common answers included a change in the amount or volume (63.7%), presence of projectile emesis (58%), emesis resembling something other than digested milk (73.9%), increased frequency of occurrence from baseline (72%), or a change in the baby's overall baseline health status from a previous shift (73.9%).

The third and final group of ten survey questions required participants to visually estimate simulated emesis volumes present on common NICU linens or disposable items, such as blue absorbent pads or dry wipes using high resolution photographs. When tabulated, participants were able to correctly estimate the volume an average of 35.5% of the time across all

ten questions. When further grouped by years of experience (table 1), education level (table 2), or presence of certification (table 3), no clear advantage was seen.

Table 1

Correct Answers by Years of Experience in Specialty Area

Experience in specialty area	1	2	3	4	5	6	7	8	9	10
> 10 years	27.8%	5.7%	12.7%	1.9%	25.3%	13.3%	7.6%	29.7%	23.4%	8.9%
≤ 10 years	34.8%	10.1%	13.9%	3.2%	29.7%	12%	8.9%	34.8%	25.3%	13.3%

Note: Heading numbers in all tables represent the ten surveyed questions

Table 2

Correct Answers by Level of Education Attained

	1	2	3	4	5	6	7	8	9	10
MSN/DNP	22.2%	6.3%	10.7%	1.3%	24%	10.7%	6.9%	26.5%	21.5%	8.9%
BSN	39.2%	10.1%	15.2%	4.4%	29.7%	13.3%	8.2%	38.6%	25%	14%

Table 3

Correct Answers by Nurses With Specialty Certification

Specialty Certification	1	2	3	4	5	6	7	8	9	10
Yes	34.8%	8.9%	17%	2.5%	31%	11.4%	7.6%	35.4%	29.1%	13.3%
No	27.8%	7.6%	10.8%	3.2%	23.4%	13.2%	8.9%	30.4%	19%	9.5%

When the percentage of correct results were arranged in ascending order of simulated volumes, wide variation in accuracy was seen as volumes increased without clear correlation to ascending values.

Table 4

Correct Answers Grouped in Ascending Order of Simulated Volumes

	2ml	2ml	5ml	5ml	5ml	20ml	30ml	30ml	50ml	75ml
Correct answer by increasing volume	63.1% (99)	28% (44)	54.8% (86)	16.6% (26)	66.2% (104)	48.4% (76)	22.9% (36)	16.6% (26)	5.7% (9)	24.8% (39)

Finally, when all answers were tabulated by experience, education, and certification, no clear advantage was seen in ability to correctly estimate simulated emesis volumes across all demographics.

Table 5

Correct Volume Estimates Across all Studied Demographics

	Total Correct
MS/MSN/DNP	34.4% (220/640)
BSN	33.9% (312/920)
Certification- Yes	34.7% (302/870)
Certification- No	34.2% (243/710)
> 10 years experience	34.1% (246/720)
≤ 10 years experience	33.6% (293/870)

Summary

Careful examination of the literature as far back as 1996 demonstrates that visual quantification of not only emesis, but trauma-related, postpartum hemorrhagic, and intraoperative blood loss is highly inaccurate. Scant research exists specific to the neonatal population, and with emesis volumes and frequency playing a critical role in feed advancement, time to full feeds, and ultimately time to hospital discharge, the need for additional information is apparent.

Current practices in a major metropolitan quaternary neonatal intensive care unit evaluated during this project reveal wide variation in nursing assessment techniques surrounding emesis quantification in neonates. These practice variations largely consisted of visual estimation of emesis volumes in term and preterm neonates and infants, which involve practices deemed widely unreliable across both neonatal, pediatric, and adult populations. This doctoral-level

quality improvement project sought to prove with meaningful data the inaccuracy of utilizing visual quantification as a method of emesis volumes in neonatal and infant populations.

Conclusion

This quality improvement project was performed in partial fulfillment of the requirements for doctoral degree completion. Despite the start of the project approval and implementation phases coinciding with the rapid rise and eventual peak of the novel SARS-CoV-2 pandemic in the New York City metropolitan area, successful project completion was attained, barriers notwithstanding. The results of this project are similar to those seen in earlier studies performed in the neonatal, pediatric, and adult populations, highlighting glaring inconsistencies in the accuracy of fluid loss measurement using visual estimation techniques.

While the results are similar to other studies across the lifespan, the information gleaned from this project continues to provide insight into the accuracy of visual estimation techniques to assess fluid volumes by healthcare providers and adds to a very small amount of research done in this area focused on the neonatal population. The data produced by this study highlights the need for more accurate methods of emesis measurement in the NICU and brings into question the utility of using estimated emesis events to guide feeding advancements by the interdisciplinary neonatology team.

Perhaps more universal use of standardized measurement systems such as weight/volume quantification using finely tuned, widely available diaper scales within the NICU would result in more rapid progression to full feeds unhindered by inaccurate data. This may result in shorter hospitalization and associated costs. Another consideration may extend in the opposite direction, revealing too-rapid increases in feeding advancement planning, which may contribute to feeding

intolerance and increased risk for intestinal complications, such as necrotizing enterocolitis, bacterial overgrowth, and malabsorption.

The limitations of this project lie in the intentionally designed narrow scope of this study. While the survey questions provided a unique view into possible factors affecting the individual nurses' accuracy in volume estimation, this project merely points in a direction in which to continue further research, as discussed in the recommendation section of this manuscript. Another limitation was the use of an online survey in place of a mobile platform used in-unit. While a necessary adaptation due to the emerging novel SARS-CoV-2 pandemic in the New York City area, it must be considered that the use of high-resolution photos in place of an in-person simulation platform perhaps exerted an effect on accuracy rates.

Regardless of the impact this increased awareness of data collection inaccuracy has on providers caring for this at-risk population, the information brought to light by this project contains the potential to point further research in meaningful directions. This project serves as a stepping-stone to many future studies regarding feeding tolerance and emesis events in the neonatal population.

Sustainability

Regardless of any project's subject or scope, consideration must be given to a means of ensuring sustainability of the best practices proposed within each manuscript. Effective means of ensuring sustainability may include nursing and organizational policy updates to better reflect ideal practices. Another method could be to provide training in emesis measurement methods during nursing orientation with a combination of didactic and clinical practice opportunities. Future research and development of improved measurement devices with national suppliers could ensure sustainability of this practice not only within this organization, but across the nation

as other organizations adopt best practices aligned with a commercially available emesis measurement product to assist them.

Recommendations

The intentional design of this project as a limited-scope qualitative data study allows guidance toward further research in this area of neonatal critical care. As the data obtained during the course of this research has confirmed what was previously known in regard to fluid volume quantification inaccuracy by providers, it guides the researcher to pursue new avenues of study. Future research opportunities could include extending this research question to examine whether implementing a standardized measurement system in place of visual quantification exerts an effect on progression to full feeds, shorter hospital length of stay, and decreased costs.

Another method could utilize quantitative rather than qualitative research to examine various methods of measuring neonatal and infant feeding tolerance outside of emesis events, such as the utility of skilled abdominal assessment, stool frequency/consistency, or weight gain velocity to determine feeding tolerance and guide advancement. Regardless of future study directions, this project adds to the existing research confirming the inaccuracy of RN visual quantification of emesis volumes in the neonatal intensive care unit setting.

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Appendix A

Letter of Institutional Board Review Exemption

NewYork-Presbyterian

Susan D. Chin, MA, RN, NNP-BC
Program Director, School Affiliations

NewYork-Presbyterian Hospital
Center for Professional Nursing Practice
466 Lexington Avenue
11th floor Box 4P
New York, New York 10017
Suc9004@nyp.org

October 15, 2020

To whom it may concern,
Steven Stoever's DNP scholarly project was approved by the NYPH Nursing Quality and Research team. It was determined that he did not need to complete the IRB process at Columbia for this project.

Please feel free to contact me should you need additional information.

Sincerely,

Susan D. Chin
Susan D. Chin, PhD, RN, NNP-BC
Program Director
School Affiliations
NewYork-Presbyterian Hospital

Appendix B

Online Google Forms data collection survey

DNP Project Survey - Stephen Stoever, RN, MSN, NNP-BC

This project is the culmination of my Doctor of Nursing Practice program of study. My goal is to utilize the skills and education I have received over the past 3 years to further enhance my knowledge and performance as a Neonatal Nurse Practitioner.

This project is entitled "Accuracy of RN Visual Quantification of Emesis Volumes in the Neonatal Intensive Care Unit"

In the neonatal ICU setting, emesis is a frequently occurring event, particularly in preterm neonates who have immature GI systems and esophageal sphincter tone. Feeding advances are planned to minimize the time central line nutrition is needed, as well as decrease exposure to TPN, which can result in liver injury and stress when used long-term. Additionally, a predictor of length of stay is linked to time to full feeds in the term and preterm neonate.

RNs often use visual estimates of emesis volumes, which are recorded in the EMR and used as part of a set of indicators to guide feed advancement. Adult studies regarding nursing quantification of postpartum hemorrhagic blood loss, trauma blood loss, and intra-operative hemorrhage have clearly demonstrated that nurses grossly under or overestimated volume loss when using visual estimation. This often resulted in complications due to underestimation of blood loss. In using visual estimation, nurses may overestimate or underestimate actual emesis loss in the neonate, resulting in a change in medical plan which could delay time to full feeds, longer indwelling catheter times, and increased length of stay.

The primary purpose of this QI project using Squire methods is to determine the statistical accuracy of RN of neonatal emesis volumes when a visual method is used.

Additional clinical questions this project seeks to answer are:

1. Are visual estimates of emesis volumes by RNs accurate?

2. Do years of experience, or attitudes toward emesis measurement/estimation affect accuracy?

3. Do we need to be as conservative as we are regarding feed advancement, and by default lengthen NICU length of stay, if we know that visual estimates are inaccurate?
4. Can we come up with better practices around measuring emesis volumes in other ways besides visual estimation?

Your help in completing these surveys is greatly appreciated! We will begin with some demographic questions about your education and experience. You will then be asked some questions about your attitudes around feeding tolerance and emesis events in neonates. Finally,

you will be shown photos of simulated emesis volumes and be asked to visually quantify each sample.

Nursing Demographics Survey

1. How many years of neonatal or pediatric nursing experience do you have?

Mark only one oval.

- ◯ 0-1
- ◯ 2-5
- ◯ 6-10
- ◯ 11-15
- ◯ 16-20
- ◯ >20 years

2. What is the highest level of nursing education you have completed? *

Mark only one oval.

- ◯ Bachelor's
- ◯ Master's
- ◯ Doctorate
- ◯ Other:

3. Where did you receive the majority of your nursing training? *

Mark only one oval.

- ◯ United States
- ◯ Outside the United States

4. Are you currently certified in your specialty area? (NCC, CCRN, RNC, etc) *

Mark only one oval.

- ◯ Yes
- ◯ No

5. Are you planning on continuing your nursing education? *

Mark only one oval.

- ◯ Yes - Master's
- ◯ Yes - Doctorate
- ◯ No
- ◯ Yes, but in something other than nursing

Nursing Attitudes Regarding Feeding and Emesis in Neonatal Patients

6. Please select all the assessment findings you use to evaluate feeding tolerance *

Check all that apply.

- ☐ Residuals aspirated from feeding tube prior to feed
- ☐ Abdominal exam (distention, bowel sounds, distended veins, etc)
- ☐ X rays
- ☐ Emesis occurrences (no volume specified)
- ☐ Emesis volumes
- ☐ Stool consistency and frequency

Other: ☐ _____

7. Are you more likely to suspect feeding intolerance in a preterm neonate vs a term neonate who are having similar emesis episodes? *

Mark only one oval.

- ◯ Yes
- ◯ No

8. In your opinion, what about an emesis episode in any neonate, regardless of gestational age, makes YOU suspect something other than normal neonatal emesis is occurring? *

Check all that apply.

- [ ] The amount or volume
- [ ] Whether it was projectile or not
- [ ] It doesn't look like digested formula or breastmilk
- [ ] The frequency it occurs on my shift
- [ ] A change from when I had the baby on a previous shift

9. When you measure emesis amounts, you are most likely to: *

Mark only one oval.

- ◯ Weigh the soiled item on a scale
- ◯ Estimate the amount
- ◯ Other:

10. Which in your opinion is the most accurate way to measure emesis volumes? *

Mark only one oval.

- ◯ Scale
- ◯ Estimate
- ◯ Other:

11. In your opinion, how do the majority of nurses in your unit measure most emesis volumes? *

Mark only one oval.

- ◯ Scale
- ◯ Estimate
- ◯ Other:

Visual Estimation of Simulated Emesis Volumes

Please evaluate the following images and choose an answer that best matches what YOU think is the accurate estimated volume of emesis.

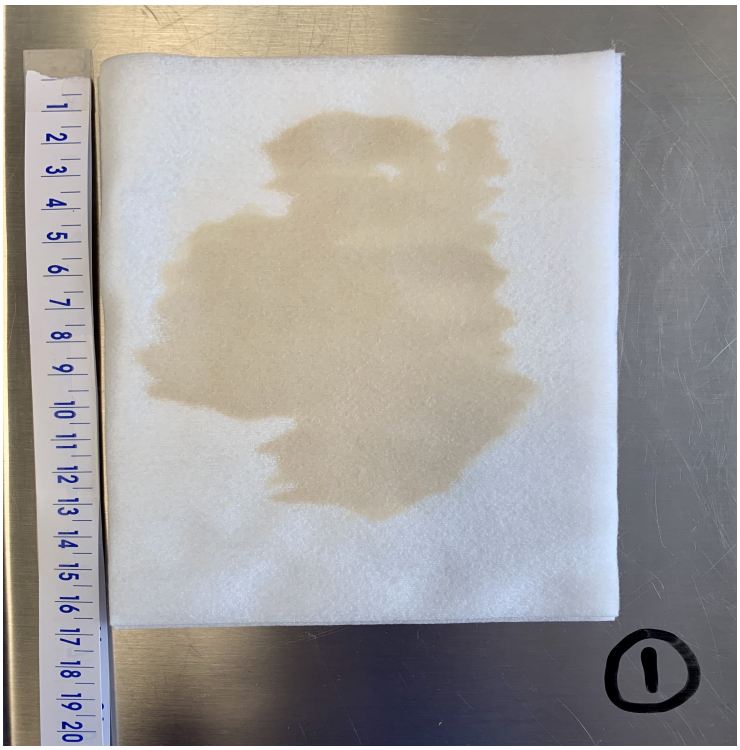
Image 1/10 - Media is one standard hospital washcloth

12. Please estimate how much emesis is on this washcloth *

Mark only one oval.

- 2 ml
- 5 ml
- 10ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

Image 2/10 - Media is two stacked dry wipes



13. Please estimate how much emesis is on this dry wipe *

- ▢ 2 ml
- ▢ 5 ml
- ▢ 10ml
- ▢ 20 ml
- ▢ 30 ml
- ▢ 50 ml
- ▢ >50 ml

Image 3/10 - Media is standard hospital baby shirt

14. Please estimate how much emesis is on this shirt *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

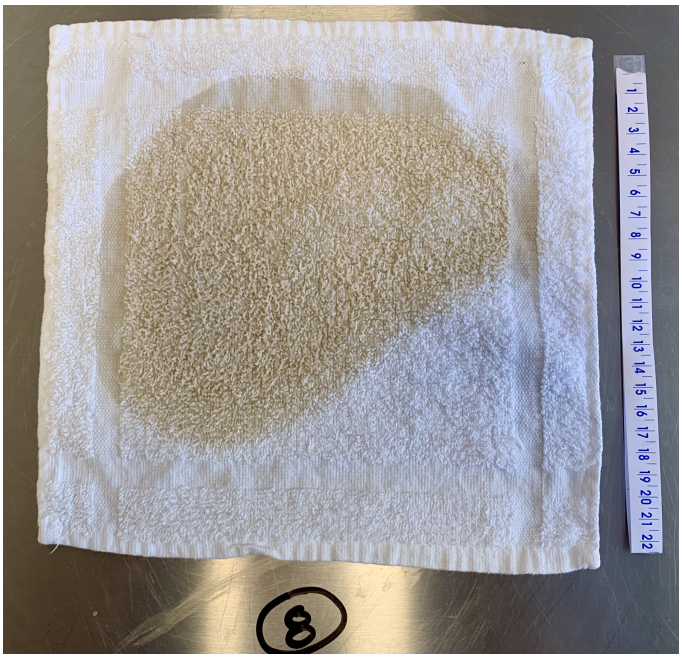
Image 4/10 - Standard hospital shirt

15. Please estimate how much emesis is on this shirt *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

Image 5/10 - Hospital washcloth

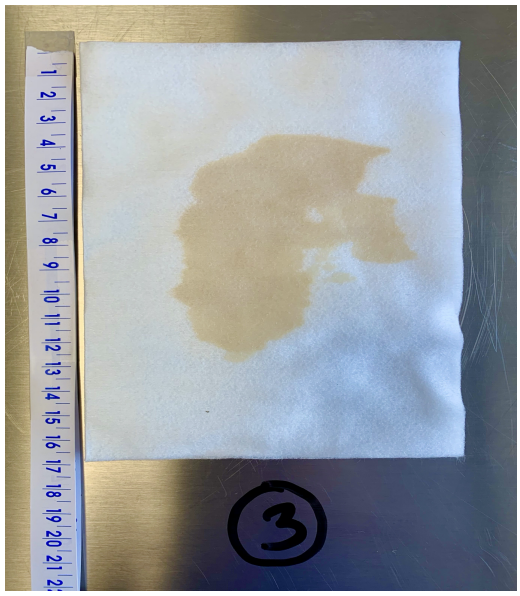


16. Please estimate how much emesis is on this washcloth *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

Image 6/10 - Standard dry wipe

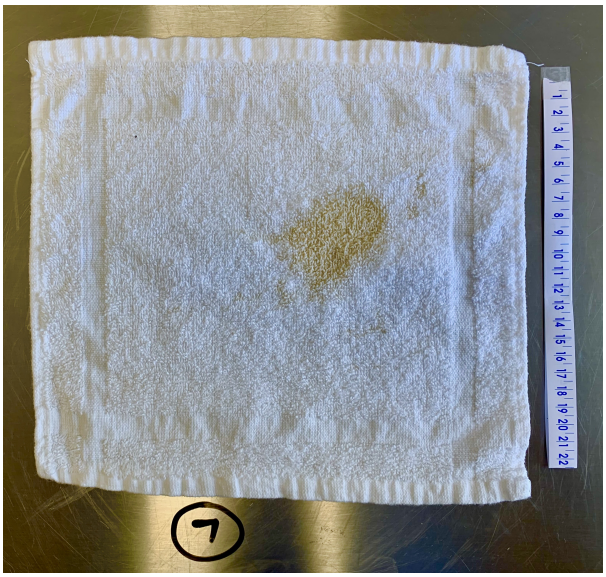


17. Please estimate how much emesis is on this dry wipe *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

Image 7/10 - Hospital washcloth



18. Please estimate how much emesis is on the washcloth *

Mark only one oval.

- ▢ 2 ml
- ▢ 5 ml
- ▢ 20 ml
- ▢ 30 ml
- ▢ 50 ml
- ▢ >50 ml

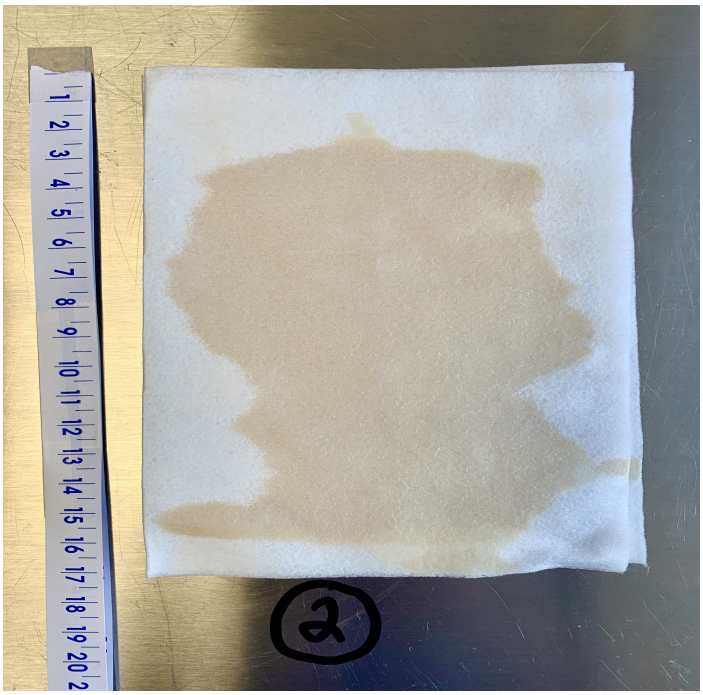
Image 8/10 - Standard baby blanket

19. Please estimate how much emesis is on the blanket *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml

Image 9/10 - Standard dry wipe

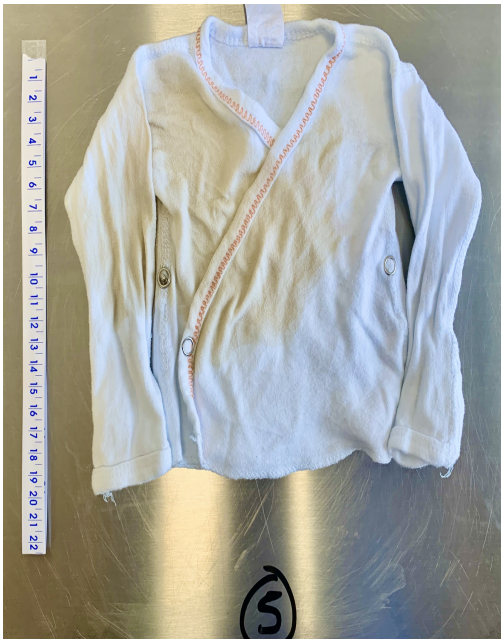


20. Please estimate how much emesis is on the dry wipe *

Mark only one oval.

- ◯ 2 ml
- ◯ 5 ml
- ◯ 20 ml
- ◯ 30 ml
- ◯ 50 ml
- ◯ >50 ml

Image 10/10 - Standard hospital baby shirt



21. Please estimate how much emesis is on the shirt *

Mark only one oval.

- 2 ml
- 5 ml
- 20 ml
- 30 ml
- 50 ml
- >50 ml