Transportable Enhanced Simulation Technologies for Pre-Implementation Limited Operations Testing: Neonatal Intensive Care Unit

Jesse Bender, MD; Robin Shields, RNC; Karen Kennally, RN, BSN

Introduction: Transition of a Neonatal Intensive Care Unit (NICU) to a new physical plant incurs many challenges. These are amplified when the culture of care is changing from traditional cohort-based care to the single-family room model. Altered healthcare delivery systems can be tested in situ with TESTPILOT: Transportable Enhanced Simulation Technologies for Pre-Implementation Limited Operations Testing. The aims of the study included promoting translation of existing processes and identifying staff orientation material. We hypothesized that (1) numerous process gaps would be discovered and resolved, and (2) participants would feel better prepared.

Methods: A functional neonatal intensive care unit was modeled before its opening. Scenarios were developed, volunteers recruited, and rooms supplied with equipment. Participants performed usual duties in two 30-minute in situ simulations followed by facilitated debriefings. As latent safety hazards were identified, they were corrected and retested in subsequent simulations. Staff was surveyed for perceived preparedness.

Results: Ninety-six multidisciplinary participants identified 164 latent safety hazards in verbal and written communication, facilities, supplies, staffing, and training, 93% of which were resolved at transition. Staff preparedness varied but showed improving communication, workflow patterns, and awareness of equipment and supply locations. The majority stated that this simulation experience changed their practice.

Conclusions: Simulation is very effective for identifying process gaps before major institutional change. TESTPILOT generated iterative workflow enhancements and staff orientation toward improving patient care at transition and beyond. The extensive coordination required to implement such large-scale simulations is well worth the benefit for systems refinement and patient safety.

Key Words: Patient safety, Operations testing, Macrosystems, Simulation, Neonatal intensive care unit, Multidisciplinary.

Women & Infants’ Hospital is a regional high-risk maternal and neonatal referral center in southeastern New England. It opened the largest single-family room neonatal intensive care unit (NICU) in United States in September 2009. Housed in the adjacent newly constructed South Pavilion, this 50,000 sq ft (4645 m²) 80-bed NICU was constructed with family-centered care in mind. Parents may now stay at their baby’s bedside 24 hours a day, which may contribute to improved developmental care. Families should experience less stress than in the traditional open cohort NICU,1,2 as well as the possibility of fewer in-hospital complications3 and improved neurodevelopmental outcomes.4 Successful translation of existing care practices to the single-family room NICU may affect each of these outcomes.

However, it was not straightforward to transition from an open bay model, with isolettes and warmers clustered in six bays, to a single-family room model of care. Care practices had evolved over decades, refined by generations of caregivers, accumulating processes that were both efficient and redundant. These processes needed to be refined to deliver equivalently safe patient care in the new facility. For example, physicians in the old model could readily identify areas of increased patient acuity, in parallel with respiratory therapists and nurses sharing responsibility for neighboring patients. In the new unit, which is five times larger, staff would function in single, twin, and triplet rooms spread over two floors. It would be a challenge for each specialty to be alerted and coordinate responses to acute situations.

In preparation for the move, preemptive changes were implemented such as building a mock room in the old facility to facilitate staff exploration of the new workflow. The medical model was altered to balance provider coverage on all shifts and create new responsibilities to accommodate for the larger distances. New technology was introduced incrementally to facilitate communication, including an electronic
medical devices were implemented first for recruiting the delivery team, then for interprovider communication, and later for sending critical labs and vital sign alerts to providers. However, despite extraordinary planning efforts, multidisciplinary workflow committees found themselves still facing many unknowns such as orchestrating a code blue or balancing nursing assignment with respect to both patient acuity and physical sight line. It was difficult to imagine how all the pieces would come together. Transportable Enhanced Simulation Technologies for Pre-Implementation Limited Operations Testing (TESTPILOT) was developed to identify how individual systems could integrate into a new equivalently safe and effective NICU environment. Healthcare educators have employed advanced simulation technology to provide controlled situational learning and improve clinician’s decision making, psychomotor skills, and team behaviors. These same techniques apply to evaluating practices untested in new clinical environments, exposing potentially harmful processes.

TESTPILOT was an observational study of a dynamically changing healthcare macrosystem. We hypothesized that (1) despite extensive planning, numerous process gaps would be discovered, and (2) participants would feel better prepared to work in the new environment as a result of these sessions. Specific aims included translation of existing processes to the new NICU and enhancement of staff preparation both by enabling a preview and by identifying key training elements for the orientation workshop.

**METHODS**

This study encompasses design of initial scenarios, optimizing timing with respect to evolving systems, and preparation and running the simulations. The Women & Infants’ Institutional Review Board approved the study with informed consents for participation and videotaping, outcome measurement, and publication.

**Scenario Details**

Scenarios were scripted by nurses, respiratory therapists, and physicians, setting stages with common situations such as management of prematurity, meconium aspiration syndrome with persistent pulmonary hypertension, seizures in the large for gestational age neonate, and cardiac arrhythmias. Each participant followed the same patient through two progressive scenarios (Table 1). Balanced assignments were built for each group of health care providers, developed for baseline chaotic realism and infused with a sense of task-oriented urgency. Twenty minutes into each session, an additional scenario was introduced, to which existing staff would have to adjust. Some of these “wildcard” scenarios were drawn from previous experiences in the NICU, and others tested geographic concerns in the new building (Table 1).

**Timing With Respect to Evolving Systems**

Simulation sessions needed to be completed with sufficient time to both address problem areas and integrate solutions into the staff orientation workshop. However, many technical systems were not expected to be completed until just before opening, so testing their integration was not feasible. Adaptations were made for the evolving functionality of the bedside monitors, electronic medical record, and wireless communication devices. For example, until wireless communication devices were programmed to send laboratory values directly to them, providers would be handed values on an index card. Six simulation sessions were scheduled between 6 and 9 weeks before the transition.

**Preparing and Running the Simulations**

Research personnel informed staff about the study and encouraged sign up on lists posted in common areas. Rooms in one-eighth of the new NICU were prepared for in situ simulation, with supplies, stocked carts, mannequins, and warmers. There were paper charts for writing orders and an active electronic medical record for documentation. Familiar monitors had simulated heart rate

<table>
<thead>
<tr>
<th>Table 1. Scenarios</th>
<th>First Scenario</th>
<th>Second Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angel</td>
<td>Premature 28 weeks, incoming transport secure endotracheal tube, set up ventilator, chest film, surfactant</td>
<td>Place central lines, hang IV fluids, write orders</td>
</tr>
<tr>
<td>Bobby</td>
<td>Resolved cardiac hydrops, no IV, hyperkalemia, premature atrial contractions, EKG</td>
<td>Hang calcium, labs sent, PACs resolve; otherwise progress to SVT, resolves with adenosine</td>
</tr>
<tr>
<td>Cassius</td>
<td>Pulmonary hypertension, meconium aspiration; elective intubation, volatile SO₂, acidosis; stressed parent</td>
<td>Improves on oscillator, bolus hypotension, vasopressors, inhaled nitric oxide</td>
</tr>
<tr>
<td>Delila</td>
<td>Late preterm LGA; seizures persist despite dextrose and phenobarbital, mom anxious and demanding</td>
<td>Serial desaturation, apnea, intubate, prepare for CT scan</td>
</tr>
<tr>
<td><strong>Wildcard</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code stork</td>
<td>Precipitous delivery of 26-week twin A on high-risk antepartum floor, then mom to OR for breech twin B</td>
<td></td>
</tr>
<tr>
<td>Code blues</td>
<td>Simultaneous cardiorespiratory crises on separate floors</td>
<td></td>
</tr>
<tr>
<td>Slow to start</td>
<td>Shoulder dystocia, in LDR, resuscitation, congenital anomalies</td>
<td></td>
</tr>
<tr>
<td>Multiple transport</td>
<td>Arranging stable transport out, incoming calls with critically ill patients from outside facilities, recruiting staff, assembling and mobilizing teams</td>
<td></td>
</tr>
<tr>
<td>Power outage</td>
<td>Addressing system failures during and after power outage</td>
<td></td>
</tr>
<tr>
<td>Rapid response</td>
<td>Call for apneic infant on postpartum unit, transport back to NICU</td>
<td></td>
</tr>
</tbody>
</table>
and pulse oximeter plethysmography, and artistic props were set to fit the particular scenario. Confederate educators, staff whose role was to sustain progression of the simulation, were given their vignettes. Members from the Family Advisory Council, security, media, and marketing were given minimal direction for their role as "parents," so we could explore staff communication and emotional support practices. Each session started with a 90-minute participant orientation to the facility, code alarms, location of equipment, and use of communication devices. Participants were reminded that individual skills were not being tested. They were then given their duty assignment and allowed time to familiarize themselves with the room. The start of the simulation was announced, and confederate educators in each room guided progression through the scenario without directing outcome. Several video recorders captured peak action segments. After a 30-minute simulation, there was 1 hour of facilitated debriefing. Participants then had a second 30-minute simulation, progressing from the first scenario, followed by a second debriefing.

Orientation Workshop

A 4-hour mandatory orientation workshop was developed and implemented before transition. The content of the workshop evolved over the course of TESTPILOT from a general concept to a program with clearly defined structure and content. The orientation planners chose to use scenario-based methodology as a result of their experience witnessing the transformation in participants from insecure to confident. The workflow committee wrote three orientation scenarios: a scavenger hunt to locate supplies, negotiating the change of shift, and the role of admission nurse. Orientation participants practiced recurrent issues identified in TESTPILOT. Staff wrote down questions for discussion during debriefing, the answers to which were later posted for all staff to review. Each participant was also given a ring of cards detailing the specific processes that had changed.

Outcomes

The primary outcome was identification and resolution of latent safety threats discovered through debriefing. The secondary outcome was staff preparedness assessed by serial qualitative questionnaires.

Data Collection

Process deficiencies were identified during group debriefing in round table format. Every participant was required to join the debriefing session immediately after each simulation. The lead debriefer sets ground rules for constructive criticism, encouraging each participant to share their opinion, facilitating toward problematic processes and away from fixation on clinical judgment errors. Video playback was used either to highlight informative interactions or to clarify a disputed progression of events. As specific topics reached saturation, they were noted, so as not to exclude other discoveries. Discussion was documented simultaneously by multiple scribes, each of whom was instructed to offer solutions in conjunction with their record. Within a week, the tabulated results were dispersed to appropriate committees, technical support, or facilities management. However, the changes were already being made. Distributed problem solving enabled efficient change by key stakeholders rather than awaiting post hoc analysis. The employee orientation workshop integrated some of these specific situations into scenario-based instruction.

Participants graded their TESTPILOT experience with our generic simulation evaluation form. Staff preparedness to work in the new environment was later assessed with a series of questionnaires. The first survey was mailed 1 month before transition (post-TESTPILOT); the second survey was completed 1 week before transition (post-workshop), as shown in Figure 1 timeline. These surveys had 11 questions, each with a Likert scale: strongly disagree, disagree, neutral, agree, or strongly agree. The third survey was an in-person four-question interview giving a broad overview of actual preparedness 3 weeks after transition.

Data Analysis

Process deficiencies were counted only once and considered a latent safety hazard if a reasonable situation could be envisioned wherein, if not corrected, patient or staff safety would be at risk. A "major" safety hazard could impede response to an acute life-threatening event if uncorrected. Latent safety hazards were further classified by the predominant characteristic as follows: "organizational" issues focused on medical team composition and responsibilities; "ergonomic" issues focused on the dynamic interaction of equipment and personnel within the physical space; "communication" patterns included both verbal and written; "facilities" identified mechanical dysfunction of the physical space, distinct from "technical" fine tuning of specific devices. A second investigator reviewed the accuracy of the classifications.

Staff surveys were analyzed for time and simulation effects. Each practitioner survey was categorized into one of three groups for analysis: TP-only experienced TESTPILOT but had not yet been through the workshop, WS-only included those workshop attendees who had not participated in TESTPILOT, and TP-plus-WS had experienced both. The proportion that responded favorably (agree or strongly agree) to each question was compared with proportional...
odds models, significant at $P$ value $<0.05$. Group comparisons between WS-only and TP-plus-WS reflect incremental doses of scenario-based education, as both the workshop and TESTPILOT used this educational methodology. Group comparisons between WS-only and TP-only offer a rough estimate of evolving systems readiness over the period of study.

**RESULTS**

**Recruitment**

Nearly half of the staff pool, 96 recruits, participated in TESTPILOT. All specialties participated: nurses, (28) physicians, (15) respiratory therapists, (11) radiology and laboratory technicians, (10) assistant nurse managers, (9) neonatal nurse practitioners, (7) and secretaries (3). They were 97% female, ranging from 21 to 61 years of age and 1 to 35 years of NICU experience. Although half had never experienced simulation, they were able to assume their assigned roles within a few minutes into each scenario. They actively contributed to the debriefing after recognizing that they were not the ones being evaluated. They contributed significantly to the NICU transition by sharing their discoveries with the greater staff, as well as volunteering to be confederates in subsequent sessions.

**Recurrent Themes**

The debriefings identified discrete latent safety hazards and also highlighted recurrent themes that had not yet been solved. These included communication practices, workflow organization for recruiting staff, crisis response times, and family interactions.

**Communication Practices to Compensate for Staff Isolation**

A prominent objective in the design of the single-family room had been to eliminate overflow of neighboring motion. This would hypothetically result in more peace and quiet for families but with the risk of staff disconnect. A neonatal fellow may no longer readily identify where he is needed most, extra hands may not be made aware of a triplet delivery, and a nurse could not readily visualize her other baby having an oxygen desaturation event. The simulations gave us repeated learning opportunities for these communication practices. For example, the use of handheld wireless phone devices to recruit the delivery room team was new to most nursing staff. They needed to practice dialing, using hotkeys, and speaking walkie-talkie style, as well as foster the habit of recruiting backup.

**Workflow Organization**

The method evolved for recruitment of support to the bedside. Three tiers of requests were delineated: routine calls, urgent calls for situations requiring a prompt assistance, and emergent calls for a life-threatening situation. For routine calls, a wall push button alerted the unit secretary; alternatively, the handheld phone could make a direct connection to the provider. For urgent calls, the previous options were available, plus the wall “staff assist” button sent a text alert to the phones of neighborhood nurses, respiratory therapists, and assistant nurse manager. For emergent calls, the wall “Code Blue” button triggered a blue light audiovisual alert in the hall, sent an alert to the code team, and initiated a conference bridge among the code team. These recruitment strategies reconfigured serially over TESTPILOT, shifting from too small of a notification group in an effort to minimize excessively frequent calls, toward expanded group awareness for critical events. Supporting processes also had to be created. Call forwarding patterns had to be programmed when phones were busy or turned off. Sending laboratory values to medical providers required their association with the patient using a network application. For nurses to identify appropriate medical providers for the day, a network spreadsheet of providers was made accessible on every desktop computer.

**Crisis Response**

Concerns about travel between the two NICU floors were settled in the initial simulations, as the number of stairwells was sufficient even when the elevators were not working. Travel routes to locations outside the NICU were highly variable until specific paths were suggested. Response times were well within tolerable expectations except when the NICU-based Infant Rapid Response Team responded to a call in the normal nursery. Once we acknowledged that the call was to first and foremost secure staff presence rather than the transport bed, response times halved, returning to previous levels.

**Interaction With Families**

Previous hospital guidelines had encouraged parents to leave during invasive procedures, such as intravenous catheter placement or endotracheal intubation. Individual cases were guided by parents’ stance, provider experience, and nursing discretion. Having built a family-centered care facility, parents’ presence was now expected during a wider spectrum of care activities. With TESTPILOT came an opportunity to model effective behaviors with parents in the room, script helpful diversions, and enable options to stay or leave during a procedure. The simulations also created some unexpected discoveries, such as a mother wandering between rooms searching for her baby on her first NICU visit; a father’s unchecked anxiety when unsupervised during his child’s resuscitation; or a parent being asked to step out and then never updated. Whether it was a novel system, a medical model framework, or a shift in the bedside culture, each of these recurrent themes in the earlier sessions provided a framework for recursive practice and refinement in later sessions.

**Discrete Latent Hazards**

Many novel discoveries emerged during debriefing. One hundred sixty-four discrete latent safety hazards were identified (Table 2). Most issues were considered minor, but 7% were major concerns such as insufficient staffing, poor communication device etiquette, and jammed glass doors. Latent hazards were distributed across communication, organizational, facilities, ergonomic, and technical issues (Fig. 2). Ergonomic corrections included repositioning ventilator supply lines within patient rooms to avoid a trip hazard when transferring a baby and lowering shelves in the storage closets. Facilities and technical corrections included releaning...
slippery floors associated with multiple near-falls, overriding poorly responsive elevators that delayed neonatal transports, and adjusting blank coverage zones for the handheld devices and overhead pager system. Other resolutions are listed in Table 2. As noted in Figure 2, the majority of TESTPILOT discoveries were resolved by practice change, becoming points of emphasis in the orientation workshop. Only 7% of these hazards were unresolved at the time of transition. Some of these hazards were not fixable such as hall obstruction by widely opened doors in the observation room. Others would be fixable later by implementation of computerized physician order entry.

### Simulation Evaluations and Preparedness Surveys

Preparedness to work in the new environment and effectiveness of the simulation were assessed separately. For the latter, 81 of 96 TESTPILOT participants from all specialties completed simulation evaluations immediately after their session. They found the simulations well organized, realistic, and relevant to their duties (Likert scale 0–5, average score [standard deviation] ranged from 4.26 [0.84] to 4.56 [0.59], see Appendix A). They cited the experience as changing their practice (4.21 [0.73]) and recommended simulation to their colleagues (4.84 [0.79]). The progressive stages of implementation thus did not detract from simulation fidelity, with the primitive monitors, older phones, and workstations being sufficient until the updated versions were available.

Preparedness surveys post-TESTPILOT, forming the TP-only group, had a poor response rate (26/96). Response rate was better (139/150) for the post-workshop survey. Thirty-one of these nurses also experienced TESTPILOT and form the TP-plus-WS group. The other 108 nurses were form the WS-only group. While nursing staff considered themselves well prepared in many facets of care (Appendix B), a notable segment of the population was either neutral or negative regarding preparedness to function, perform resuscitation, or care for a critically ill neonate. Most providers rated patients as safer as a result of this training. However, at the time of transition to the new environment, more than one-third indicated a need for further orientation. The WS-only group responded more favorably than the earlier TP-only group on questions regarding awareness of supply locations, equipment location, communication, and workflow patterns (Appendix C). Both groups experiencing TESTPILOT were more in favor of using scenario-based techniques in the orientation workshop. The response to other preparedness questions did not differ significantly between groups.

Brief interviews with 171 (76% of staff) nurses, physicians, respiratory therapists, and nurse practitioners were done 3 weeks after transition. Most (81% of surveyed) agreed that scenario-based training had prepared them to function in the new environment. Although before transition many (42%) staff reported insufficient orientation to start working in the new environment, the majority (78%) had settled in within 3 weeks of transition. Half of the staff interviewed was unaware of how much TESTPILOT contributed to the workshop development, but more TESTPILOT participants (73% versus 37%) were aware of discoveries addressed before the move.

**Figure 2.** Categorization and resolution of latent hazards at transition.

### Discussion

Simulation has been used for decades in healthcare to analyze microsystems such as adverse event analysis, medical device design, human factors evaluation on pediatric sedation teams, and environment testing in a transport helicopter. Simulated disasters have been used to test hospital surge capacity. Simulation protocols have been used to orient

**Table 2.** Latent Safety Hazards

<table>
<thead>
<tr>
<th>Number Identified</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication processes written and verbal orders, call flow at secretarial hubs</td>
<td>35</td>
</tr>
<tr>
<td>Code event workflow</td>
<td>7</td>
</tr>
<tr>
<td>Admission staging</td>
<td>15</td>
</tr>
<tr>
<td>Mobilizing delivery and rapid response teams</td>
<td>16</td>
</tr>
<tr>
<td>Laboratory and radiology</td>
<td>11</td>
</tr>
<tr>
<td>Family-centered care provision</td>
<td>10</td>
</tr>
<tr>
<td>Safety issues</td>
<td>11</td>
</tr>
<tr>
<td>Facilities and supplies</td>
<td>36</td>
</tr>
<tr>
<td>Staffing</td>
<td>11</td>
</tr>
<tr>
<td>Training</td>
<td>12</td>
</tr>
</tbody>
</table>
The TESTPILOT concept, focusing on preimplementation testing of a new healthcare facility, originated with the opening of the Rhode Island Hospital adult emergency room in 2005. In situ simulations of cardiac arrest, multiple trauma, septic shock, and pediatric toxicology cases were run 4 days before its opening, identifying multiple operations issues. In situ obstetric simulations have been used to resolve latent safety hazards and analyze the breakdown of redundant safety nets in sentinel events. However, until now, full-scale immersive macrosystem level simulation has had limited application due to cost and complexity. Women & Infants’ Hospital workflow subcommittees had brainstormed complications of this transition as much as possible without actually doing it. TESTPILOT-NICU uniquely transported systems evaluation in situ, in an intensive care unit, on an unprecedented scale, before moving patients to the new facility.

TESTPILOT succeeded only in the context of widespread participant vesting. Building upon months of preparation by the core simulation team, recruits were engaged from bioengineering, facilities, information technology, marketing, media, nursing education, and risk management. Neonatal fellows, nurses, and assistant nurse managers shared their time and expertise. The NICU medical director, pediatric department chief, and nurse manager were front-line participants. All participants did their jobs well in the simulated environment, given realistic nursing assignments, challenging scenarios, and familiar tasks. The presence of stressed “parents” increased the level of realism, drawing participants’ attention from some of the less realistic artifacts of simulation. Aligning the focus of such a diverse and vested group of participants generated rich discussion and productive troubleshooting.

Simulation drove the evolving readiness of facilities, alarm systems, and computer networks and handheld communication devices. The latter grew from team coordination to critical events, to vital sign alerts for nurses, to abnormal laboratory reporting for providers. Arbitrary vital sign trigger limits were revised. Providers practiced patient association via a new web interface, as well as critical laboratory response in compliance with industry guidelines. Improved processes were integrated into subsequent simulations for further testing. The widespread use of handheld communication devices necessitated a patient-provider directory that was widely accessible and easily updated, so multiuser spreadsheets were created with icon access at every documentation station. The details for practice in the new NICU did not fall into place until simulation highlighted existing deficiencies in process and opportunities for correction.

Numerous patient and staff safety hazards were identified, including communication, organizational, ergonomic, technology-related, and facilities issues. Most safety issues were minor and were corrected by feedback through workflow committees. Uncorrected major safety hazards were addressed by training on the hazard during orientation. For example, each patient room has a sliding glass door to the hallway, enabling open sight lines for nursing care in multiple rooms. These glass doors slide open for routine entry, close for privacy, or can be derailed inward to bring in large equipment. A derailed door will jam if not properly re-engaged. As we discovered during simulation, if the door becomes derailed, the staff and patient can be trapped inside or outside the room. This isolates both nurse and neonate from other staff and can dramatically affect outcome of crisis. Proper use of these doors became part of the content in the staff orientation workshop.

While surveys quantify opinion, they highlight the foundation of all NICU care practices: nursing readiness. Nursing readiness is requisite to successful environmental change. A critical mass of our nurses did not report being well prepared before transition, which suggests potential for clinical ramifications. However, no harmful events were documented during transition, and the majority of nurses stated that they felt settled in within 3 weeks. This readiness was substantiated by team performance, when four extremely low-birth weight neonates were admitted one evening during the first week. Evolving systems readiness was supported by the increasingly favorable responses from the TP-only to WS-only groups. Selection bias may have been introduced given the poor response rate on the initial preparedness survey and the preference for scenario-based training among groups who experienced TESTPILOT.

When large-scale interventions are implemented, they change the conditions that made them work in the first place. Along the implementation chain, each simulation tested a new context. The environment at the orientation workshop differed markedly from that in the first TESTPILOT simulation, yet was the same for all workshop participants. This is supported by equivalent reporting between the WS-only and TP-plus-WS groups. Complex service interventions in a medical education environment are neither smooth nor easy in any transitioning facility. An accelerated evolution is expected when simulation is incorporated, provided that the scenarios are realistic, the debriefings constructive, the latent hazards corrected, and the processes refined.

CONCLUSIONS

When faced with large-scale culture shifts in health care, patient care cannot be compromised. In situ macrosystem simulation was effective in identifying 164 process gaps before major institutional change. The scope and complexity of TESTPILOT-NICU was unprecedented, integrating both systems testing and staff orientation by modeling a functional neonatal intensive care unit before its opening. Each discipline engaged in their native roles to generate insightful corrections and “parents” highlighted opportunities for providing truly family-centered care. Serial simulation enabled iterative improvement in 93% of latent safety hazards in a largely simulation-naive institution. The extensive coordination required to implement large-scale simulations is well worth the benefit for systems refinement and patient safety.
APPENDIX A
WOMEN AND INFANTS’ HOSPITAL SIMULATION EVALUATION SUMMARY

Adapted from Rhode Island Hospital Medical Simulation Center
Completed at end of each TESTPILOT session

5-point Likert scale scores (mean: 1 strongly disagree/poor; 5 strongly agree/excellent)

<table>
<thead>
<tr>
<th>Date</th>
<th>Objectives clear</th>
<th>Objectives met</th>
<th>Course education</th>
<th>Relevancy</th>
<th>Scenarios realism</th>
<th>Sim env realism</th>
<th>Debrief quality</th>
<th>Overall</th>
<th>Knowledge</th>
<th>Effectiveness</th>
<th>Impact on learner practice</th>
<th>Recomm</th>
<th>simulation</th>
<th>to peers</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/17/09</td>
<td>4.2±1.1</td>
<td>4.3±1.1</td>
<td>4.4±1.2</td>
<td>4.8±0.4</td>
<td>4.8±0.4</td>
<td>4.9±0.4</td>
<td>4.7±0.6</td>
<td>4.8±0.4</td>
<td>4.7±0.5</td>
<td>4.7±0.5</td>
<td>4.3±0.6</td>
<td>5.0±0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/27/09</td>
<td>4.2±0.7</td>
<td>4.2±0.7</td>
<td>4.4±0.6</td>
<td>4.4±0.6</td>
<td>4.0±0.9</td>
<td>4.1±0.9</td>
<td>4.4±0.6</td>
<td>4.3±0.7</td>
<td>4.5±0.5</td>
<td>4.4±0.6</td>
<td>4.3±0.8</td>
<td>4.8±0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/5/09</td>
<td>4.4±0.6</td>
<td>4.3±0.7</td>
<td>4.4±0.6</td>
<td>4.6±0.6</td>
<td>4.4±0.7</td>
<td>4.3±0.7</td>
<td>4.5±0.6</td>
<td>4.5±0.6</td>
<td>4.4±1.1</td>
<td>4.5±0.5</td>
<td>4.1±0.8</td>
<td>4.7±1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participant Suggestions from simulation

"Keep simulation going"
"Better communication. Any baby in SCN should have a heel type with intial blood work"
"Ease of finding room"
"Better communication"
"Have a neonat in each room, to have different ringtones for different teams on ASCOM phones"
"Very good experience"
"Need more aides"
"Have more buddies"
"Excellent, very useful, practical"
"This would be more relevant if areas were stocked, all equipment available and normal staffing"
"Communication"
"More signage for directions"
I would like more opportunities to explore new unit and connections to other parts of the hospital"
"Could we extend these mock trials?"

APPENDIX B
PRETRANSITION PREPAREDNESS SURVEYS (*P < 0.05 COMPARED TO WORKSHOP-ONLY GROUP)
APPENDIX C
PRETRANSITION PREPAREDNESS SURVEYS

<table>
<thead>
<tr>
<th>Question</th>
<th>Group</th>
<th>Timing</th>
<th>Post-TESTPILOT</th>
<th>Post-Workshop</th>
<th>P**</th>
<th>P***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparedness to function</td>
<td>TP only (n=26)</td>
<td>Post-TESTPILOT</td>
<td>Favorable*</td>
<td>Favorable**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepared to perform resuscitation</td>
<td></td>
<td>WS only (n=108)</td>
<td>62% 0.958</td>
<td>56% 0.548</td>
<td>50% 0.065</td>
<td>55% 0.158</td>
</tr>
<tr>
<td>Comfortable caring for critically ill</td>
<td></td>
<td>TP plus WS (n=31)</td>
<td>65% 0.085</td>
<td>44% 0.548</td>
<td>65% 0.459</td>
<td>55% 0.981</td>
</tr>
<tr>
<td>Able to recruit assistance</td>
<td></td>
<td></td>
<td>65% 0.37</td>
<td>79% 0.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication systems tested</td>
<td></td>
<td></td>
<td>35% 0.003</td>
<td>50% 0.468</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily workflow clear</td>
<td></td>
<td></td>
<td>38% 0.005</td>
<td>57% 0.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able to locate supplies</td>
<td></td>
<td></td>
<td>38% 0.001</td>
<td>66% 0.697</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment accessibility</td>
<td></td>
<td></td>
<td>54% 0.032</td>
<td>75% 0.298</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients safer at transition</td>
<td></td>
<td></td>
<td>77% 0.183</td>
<td>71% 0.824</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario based orientation</td>
<td></td>
<td></td>
<td>85% 0.001</td>
<td>70% 0.046</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need further orientation (negative)</td>
<td></td>
<td></td>
<td>42% 0.648</td>
<td>37% 0.402</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* % agree or strongly agree
** P value for comparison to Workshop-only group
APPENDIX D

POSTTRANSITION SURVEYS (NOT STATISTICALLY DIFFERENT)

ACKNOWLEDGMENTS

The authors thank the essential contributions of Stephanie Adam, MaryAnn Garrin, Dan Gingras, Virginia McCann, John Tanner, MaryBeth Taub, and all the confederates, without whom TESTPILOT would not have flown.

REFERENCES


