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Folafoluwa O. Odetola

Renee R. Anspach

Yong Y. Han

*Children's Mercy Hospital*

Sarah J. Clark

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## Interhospital Transfer of Children in Respiratory Failure: A Clinician Interview Qualitative Study

Folafoluwa O. Odetola, MD, MPH<sup>1,2</sup>, Renee R. Anspach, Ph.D<sup>3</sup>, Yong Y. Han, MD<sup>4</sup>, and Sarah J. Clark, MPH<sup>2</sup>

<sup>1</sup>Department of Pediatrics and Communicable Diseases, Division of Pediatric Critical Care Medicine, University of Michigan Health System, Ann Arbor, MI

<sup>2</sup>Child Health Evaluation and Research Unit of the Division of General Pediatrics, University of Michigan Health System, Ann Arbor, MI

<sup>3</sup>Department of Sociology, University of Michigan, Ann Arbor, MI USA

<sup>4</sup>Department of Pediatrics, Children's Mercy Hospital, Kansas City, MO

### Abstract

**Purpose**—To investigate the decision making underlying transfer of children with respiratory failure from Level II to Level I pediatric intensive care unit (PICU) care.

**Methods**—Interviews with 19 eligible Level II PICU physicians about a hypothetical scenario of a 2 year old girl in respiratory failure:

**Baseline:** Ventilator settings: rate 25, peak inspiratory pressure 28, positive end-expiratory pressure 8, fraction of inspired oxygen (FIO<sub>2</sub>) 100%.

**Escalation Point (EP) 1:** After 8 hours. Higher ventilator settings; oxygenation index (OI) 32.

**EP 2:** Three hours later. OI 40.

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Corresponding Author: Folafoluwa O. Odetola, MD, MPH., 6C07, 300 North Ingalls Street, Ann Arbor, Michigan, USA 48109. fodetola@med.umich.edu, Phone: 734 615 8418.

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FOO had full access to the data and takes responsibility for the integrity of the data and the accuracy of the data analysis. FOO participated in study conception and design, data acquisition and interpretation, drafting of the manuscript, and critical revision of the manuscript for important intellectual content.

RRA participated in study conception and design, interpretation of the data, and critical revision of the manuscript.

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**Results**—At baseline, indices critical to management were: OI (53%), PaO<sub>2</sub>: FIO<sub>2</sub> [P/F] (32%), and inflation pressure (16%). Poor clinical response was signified by high OI, inflation pressure, and FIO<sub>2</sub>; and low P/F. At EP 1, 18/19 respondents would initiate high frequency oscillatory ventilation—HFOV, and one would transfer. At EP 2, 15/18 respondents would maintain HFOV, 9 of them calling to discuss transfer. All respondents would transfer if escalated therapies failed to reverse the patient’s clinical deterioration.

**Conclusion**—Interhospital transfer of children in respiratory failure is triggered by poor response to escalation of locally available care modalities. This finding provides new insight into decision-making underlying interhospital transfer of children with respiratory failure.

### Keywords

Patient transfer; child; intensive care units; critical illness; interview; therapeutics

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## Introduction

Critically ill and injured children receive care within pediatric intensive care units (PICUs) that are categorized as either Level I or II based on availability of specialized technology and subspecialty capability [1]. Published guidelines urge transfer of children that are physiologically unstable or with high risk of mortality, from Level II to Level I PICUs where they might benefit from ready access to specialized technology and subspecialists [1]. Importantly, however, the guidelines neither outline criteria to be used to identify which patients to transfer to Level I PICUs, nor the timing of transfer that might ensure the best outcomes.

Of all sources of admission to Level I PICU care, interhospital transfer admissions from Level II PICUs are associated with the highest mortality burden and hospital resource consumption [2, 3]. Also, higher severity of patient illness at the time of transfer hospitalization to the Level I PICU has been associated with greater resource consumption and heightened patient mortality at the Level I PICU [4]. Among children who underwent transfer from several Level II PICUs to a single Level I PICU, respiratory failure was a leading cause of mortality, signifying a vulnerable population worthy of study [4]. The decision making underlying transfer of these children at high risk of poor outcomes is poorly understood.

In-depth investigation of the decision-making process underlying transfer of critically ill children with respiratory failure was therefore conducted to determine factors that influence the decision to transfer by Level II PICU physicians when managing pediatric respiratory failure. It was hypothesized that patient transfer from Level II PICU care to Level I PICU care would be influenced by physicians’ clinical judgment regarding the perceived need for advanced medical technology and subspecialty capability unavailable locally.

## Materials and Methods

### Study Design

Qualitative study involving in-person semi-structured interviews.

## Delineation of PICU Levels of Care

Definition of the Levels of PICU care was in line with prior published guidelines [1]. The level I PICU had to provide multidisciplinary definitive care for a wide range of complex, progressive, and rapidly changing medical, surgical, and traumatic disorders occurring in pediatric patients of all ages, excluding premature newborns. While level I PICUs had to have a full complement of medical and surgical subspecialists, a level II PICU was not required to have the full spectrum of subspecialists. Further, the Level II PICUs could not provide extracorporeal membrane oxygenation (ECMO) for children in respiratory failure.

## Study Sample

Attending faculty physicians at seven Level II PICUs in Michigan and Northwest Ohio.

## Interview Administration

All nineteen eligible attending physician faculty at seven referring level II PICUs in Michigan and Northwest Ohio were contacted by electronic mail and invited to participate in the study. They all agreed to participate in the study. Interviews were conducted in person by one of the investigators (FOO), between April, 2013, and January, 2014. All participants were given a \$50 gift card as a token of appreciation for their time.

## Interview Instrument

A semi-structured interview instrument was created (Appendix) and pilot-tested with several pediatric intensivists outside the study's target geographic area. The interview guide led respondents through a series of questions regarding their management of critically ill children with respiratory failure or septic shock. This report summarizes the findings regarding management of respiratory failure. A hypothetical scenario of a 2 year old girl with respiratory failure from severe influenza pneumonia was presented, focusing on three points in time:

**—Baseline—**The child is admitted to the PICU via the emergency department and her clinical condition deteriorates, necessitating endotracheal intubation for respiratory failure 3 hours after initial presentation to the PICU. Mechanical ventilation settings are: rate of 25 breaths/minute, peak inspiratory pressure of 28 centimeters of water (cmH<sub>2</sub>O), positive end-expiratory pressure of 8 cmH<sub>2</sub>O, fraction of inspired oxygen concentration (FIO<sub>2</sub>) of 100%. Partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) is 140 mm of mercury (mmHg). Central venous and peripheral arterial catheters are inserted. *The respondents were asked which indices of oxygenation or ventilation they routinely measured to assess response to therapy, followed by rating of the clinical usefulness of 5 indices presented to them (Appendix). Thereafter, they indicated how often they measured clinical indices and identified values of the indices concerning for lack of response to treatment.*

**—Escalation Point #1—**After 8 hours, PaO<sub>2</sub> is 59 mmHg on higher ventilator settings with mean airway pressure (Mean Paw) of 19 mmHg and oxygenation index (OI) of 32.

Respondents estimated the likelihood of clinical turnaround if care was not escalated and were asked if they would call a Level I PICU to discuss management

or transfer (Appendix). They were also asked which adjunctive therapies they would attempt and when such therapies would be deemed ineffective. They were probed regarding the use of certain therapies if not mentioned yet (high frequency oscillation, surfactant, inhaled nitric oxide).

**–Escalation Point #2—**Mean Paw of 26 mmHg, with OI of 40.

Respondents discussed their next step in management. Thereafter, they discussed their perceptions of the inter-hospital transfer process and how it could be improved. They subsequently discussed their recent transfer practice, highlighting contributory factors. Finally, respondents discussed and ranked 7 topics as potential catalysts for further collaboration between Level I and II PICUs (Appendix).

### Data Management and Analysis

7 Interviews were audio-recorded and transcribed verbatim, to enable comprehensive analysis of their content. Transcribed data were imported into ATLAS/ti (Berlin, Germany) software for content categorization. Analysis of the transcripts was undertaken, with open coding of data and subsequent sorting into meaningful categories by the principal investigator (FOO). Categories were developed until every unit of content was categorized and the relationships between categories were established in an iterative process involving all the study investigators. The data were arranged into sections for each category, with distilled summaries of views and experiences. The Institutional Review Board of the University of Michigan Medical School approved the study.

## Results

### Baseline

Respondents varied in their use of clinical indices in the routine care of children with respiratory failure: blood gas tension (12 [63%]), OI (9 [47%]), pulse oximetry (6 [32%]), PaO<sub>2</sub>/FIO<sub>2</sub> [P/F] (6 [32%]), and either ventilator inflation pressure or tidal volume (4 [21%]). When asked to rate the clinical usefulness of various indices of respiration presented to them (Appendix), two-thirds of the respondents felt OI and P/F were very good, while approximately half felt the other indices were fair at best (Figure 1). Alveolar-arterial oxygen gradient was not used at all by 16% of the respondents. 10 of 19 (52%) respondents reported no barriers to retrieving the indices, while others reported arterial access (6 [32%]), laboratory turn-around time (1 [5%]), plateau pressure determination (1 [5%]), and time to calculate the indices (1[5%]) as barriers to use of the indices in their routine care of children in respiratory failure.

Indices regarded as most critical to the respondents' management of pediatric respiratory failure were: OI (10 [53%]), P/F (6 [32%]), inflation pressure (3 [16%]), and alveolar-arterial oxygen gradient (2 [11%]). Two (11%) respondents did not have any specific indices they felt were critical to their management of respiratory failure. Signals that raised concern for poor clinical response to therapy and the need to escalate care included elevated OI (11 [58%]), high inflation pressure (7 [37%]), high FIO<sub>2</sub> (5 [26%]), and low P/F (4 [21%]).

**Escalation Point #1**—Eight hours beyond the baseline point, the patient is on higher ventilator settings (Appendix). At this juncture, 71% (12/17) of the respondents felt the patient had < 50% probability of clinical turnaround without escalation of treatment. The next step taken by 18 (95%) respondents would be to initiate high frequency oscillatory ventilation [HFOV].

“I will strongly consider oscillating this patient on a high frequency oscillator.”

“This is not a very high mean airway pressure.....it’s a terrible oxygenation index..... I might switch, do you know what I mean, to like an oscillator.”

“PaO<sub>2</sub> of 59, terrible oxygenation index, A-a gradient is probably more than 600 this is the patient I would have, probably sooner, placed on high frequency ventilator already.”

The nineteenth respondent would transfer the patient at this juncture to a PICU with capability to provide ECMO.

“I would transfer this girl for ECMO evaluation. This girl will not be in my unit.”

Notably, a respondent’s decision regarding the use of HFOV was tempered by concern for feasibility of transport if HFOV was instituted.

“I guess first of all, if this has been 8 hours..... I’d likely contact a center and explain I have this patient, and there may be the limitation of being unable to transport a patient who is on the oscillator.”

Further evidence of the fluid nature of the decision making was illustrated by the observation that four of the eighteen (22%) respondents who would initiate HFOV at this juncture would simultaneously arrange for transfer of the patient for evaluation of ECMO therapy, while two (11%) others would call the receiving hospital to discuss management options and indications for potential transfer in the near future.

I would be getting on the oscillator and calling for transfer of this kid.”

“I would try at least maybe 4 hours tops, oscillator. I should see some change in the PaO<sub>2</sub> and the OI, but if I don’t see any change or actually if she’s getting worse, I’ll just go for ECMO.”

“So, at this point, probably I will contact a different hospital and say “you know, I have a sick patient, I’m doing this and this, and how is your bed situation?”, and if the patient turns around, then great and stabilized in the interim on an oscillator, surfactant use, some nitric, wonderful, but you’ve got to seriously consider where will you fly this patient out to.”

Of note, three of the eighteen (17%) respondents who would deploy HFOV felt airway pressure release ventilation was an alternative ventilator mode they might attempt.

In response to a question regarding the use of adjunctive therapies at this juncture, a trial of inhaled nitric oxide (iNO) therapy would be attempted by three (16%) respondents while six (32%) others would consider the use of iNO only if indicated by the clinical picture, for instance, a respondent would consider its use only if there was evidence of pulmonary

hypertension on echocardiogram. On an instructive note, while a respondent felt initiation of iNO therapy might preclude interhospital transfer:

“Nitric oxide...yes, one can give a trial of nitric oxide here. See though the one problem I get into with Nitric oxide is that...I don't know whether you guys can transport nitric oxide or not...”

another respondent reported that unavailability of iNO therapy might be a potential driver of transfer:

“I don't have nitric oxide therapy here so if I think the patient needs it, then definitely I will be initiating some talks with other institutions.”

Regarding administration of other adjunctive therapies at this juncture, three (16%) respondents would administer surfactant therapy, while four (21%) others noted that they would not. One (5%) respondent would institute continuous renal replacement therapy if there was azotemia or evidence of fluid overload.

**Escalation Point #2**—In response to further progression of the patient's illness severity, with resultant increase in the ventilator settings (Appendix), the only respondent who would have transferred at escalation point #1 maintained the same stance of transferring the patient. Among the other 18 respondents, 15 (83%) would maintain HFOV— with 9 of these 15 (60%) simultaneously making phone calls to discuss transfer – while 3(17%) respondents would transfer the patient to a Level I PICU with ECMO facilities.

“Well, I would have already sent the patient out.”

“Well, since she's still mine, she's 100 percent for sure getting transferred!”

When queried regarding the use of adjunctive therapies at this juncture, 6 (32%) of 19 respondents would not use them.

“Now we are losing our window of opportunity for transfer in my mind, if I were going to implement those things (adjunctive therapies) it should have been done, hours ago. I think at this point, the writing is on the wall... We have a short window of transfer opportunity I think I would transfer her for potential ECMO.”

“No, I think especially with her kind of previously normal physiology...those things (adjunctive therapies) are in consideration but there is no great evidence that a previously healthy influenza patient is going to immediately benefit from it (adjunctive therapies).”

However, some other respondents would try adjunctive therapies including iNO therapy (7 [37%]), surfactant (4[21%]), continuous renal replacement therapy (1 [5%]), inhaled beta-2 agonists (2 [11%]), inhaled prostacyclin (1 [5%]), and prone positioning (1 [5%]).

“...probably, in addition to beginning the process of transport, I would be starting Nitric here.”

“This was a perfectly healthy, not asthma patient, but I would try to use beta 2 agonists in this patient to see, because it's not only an oxygenation problem it's definitely a ventilatory problem too.”

“So these numbers are obviously within the ECMO range if things do not change over the coming 4 hours or so. So, what I’m going to do is definitely, I’m going to put Nitric in the picture if it is not, and I’m going to abandon conventional ventilation at this point.”

### **Duration of mechanical ventilation as a trigger for transfer**

In response to questions regarding transfer of a patient in respiratory failure based on duration of mechanical ventilation during an index hospitalization to their PICU, only 4 of the 19 (21%) respondents would consider transfer to a level I PICU based solely on duration of mechanical ventilation. The 15 others did not consider the duration of mechanical ventilation an important trigger for transfer and felt other considerations such as illness severity, the presence of acute respiratory distress syndrome (ARDS), and suitability for ECMO were more germane to their decision-making. Notably, all four respondents who would consider transfer based on duration of mechanical ventilation were most concerned about ensuring patient suitability for ECMO and considered the influence of factors other than duration of ventilation such as patient age, clinical course, and amount of ventilator support in their decision making.

“Yes. There is...if you are in ARDS, yes I think it would be ideal, if you are going to use ECMO, to get transferred and get started, I would probably give them a week. And then, you know, once you are within that first week I think I would try to get them out by the end of the week so there is time there. If it’s too long, then you get into the later stages of ARDS then I think it’s not as useful, you don’t get as much benefit.”

“The timeline comes into play if you lay out sequentially a child like this who is getting worse and if that child is heading towards an invasive need such as ECMO, we would like to do that within the first five to seven days of stay here; but as long as there is not that progression to that severity, there is not a timeline that says if a patient is ventilated for seven days, we’ve got to send them somewhere.”

“My practice has been... with most patients I try not to ventilate them at high settings for more than 7 days.

Of note, decisions about when to transfer to Level I PICU care typically were conditioned on poor response to locally available therapies as all respondents would call for transfer for ECMO if the escalated therapies failed to reverse the patient’s clinical deterioration as evidenced by lack of response to HFOV and or iNO therapy, persistently elevated OI, or persistently poor oxygenation (Table 1).

### **Potential factors that might influence patient transfer decision making**

Respondents reported that within the year prior to the study, transfer had been influenced by need for subspecialty care (89.4%), need for ECMO (84.2%), parental or caregiver desire (68.4%), and need for CRRT (36.8%), in descending order of frequency (Figure 2). When asked for their perception of the interhospital transfer process, the majority (14/19[74%] of respondents found the need to make multiple phone calls to the Level I PICU burdensome (Table 2). They preferred making a single phone call to arrange transfer, preferably to the



attending physician at the receiving hospital. When asked to rank potential future opportunities to enhance collaboration among Level I and II PICUs, the respondents most often ranked feedback from Level I PICUs as the top issue. (Figure 3)

## Discussion

The decision to transfer a critically ill child in respiratory failure from Level II to Level I PICU care is challenging and appears to hinge on whether or not the child responds to locally available therapeutic modalities at the referring hospital. This in-depth interview study of decision making by referring PICU physicians revealed that transfer is triggered by poor response to escalation of locally available intensive care modalities while clinical response obviates the need for transfer.

The timing of the transfer decision is important given worse outcomes with delay in transfer reported among critically ill adult patients [5, 6]. The study findings shed some light on the process involved in the decision making underlying transfer or non-transfer of a critically ill child with respiratory failure from Level II to Level I PICU care. This improved understanding of the transfer decision-making process has two potential advantages: greater insight into the hitherto poorly studied arena of clinical practice within the Level II PICU setting and identification of the factors germane to transfer decision-making as reported by the frontline healthcare providers who orchestrate the transfers.

Within the Level II PICU, the OI and P/F were rated as very good indices to assess the severity of the patient's respiratory failure. In comparison to other indices, the OI was felt to be most critical to management of patients with elevated values raising concern for poor response to therapy. This observation appears to be in line with existing reports of an association of elevated OI with mortality among mechanically ventilated children [7, 8].

The current study highlights the inherent challenges faced by physicians at the referring PICUs. The care of children with respiratory failure falls under the purview of most PICU physicians regardless of their practice setting. Management of respiratory failure therefore provides opportunity for trial of various therapeutic modalities and approaches which might lead to clinical improvement and obviate the need for transfer. On the contrary, however; among patients with poor clinical response to these therapeutic trials, there might be consequential delay in transfer for escalated care with resultant clinical deterioration due to progression of disease. Such clinical worsening might imperil or prohibit the transfer process, and might lead to death at the Level I or II PICU setting or during interhospital transport.

It is therefore important to determine when to transfer those severely ill children unresponsive to therapy at the Level II PICU care setting prior to onset of severe or irreversible organ dysfunction which is associated with heightened mortality risk. To this end, prior studies have reported an association between longer duration of pre-ECMO mechanical ventilation and poor patient survival [9–11]. Of note, the majority of respondents in the current study did not consider the duration of mechanical ventilation during an index hospitalization an important trigger for transfer and felt other considerations such as illness

severity, the presence of ARDS, and suitability for ECMO were more germane to the decision making than the duration of mechanical ventilation solely. This is an instructive finding of importance to improved understanding of the inter-PICU transfer decision-making process.

Progression of disease severity, as illustrated in the scenarios posed to the referring physicians, led to escalation of ventilator support often to non-conventional ventilator modes, predominantly HFOV. The majority of the respondents stated that the patient was unlikely to improve clinically without escalation of support. At the initial escalation point with elevated OI, approximately 1/3<sup>rd</sup> of the respondents would call for management advice and initiate discussions about transfer; only one respondent would transfer. At the second escalation point, however; three respondents would transfer while nine would call a Level I PICU to discuss management and potential transfer.

Of the adjunctive therapies that might be instituted at the Level II PICU setting, inhaled nitric oxide therapy was most often selected. This finding was instructive given that recent studies suggest that while inhaled nitric oxide therapy might reduce the duration of mechanical ventilation, it does not improve survival for children with acute respiratory distress syndrome (12, 13). Nonetheless, a referring physician was concerned about the use of inhaled nitric oxide therapy if it could not be administered enroute the receiving hospital. Similar concern was raised regarding institution of HFOV therapy as it might preclude transfer given that it is not routinely delivered during transport. These observations highlight potential barriers to timely and safe patient transfer and raise the need to consider all viable transport options including the cannulation of patients onto ECMO at the referring hospital prior to transfer [14, 15] or institution of innovative transport processes, as illustrated in a recent report of patient transport on HFOV, a procedure previously deemed impossible [16]. The risks associated with transport deserve due consideration in any transfer decision-making process in order to not jeopardize patient safety either via disruption of ongoing intensive care or from progression of disease during transport without the ability to maximally support the patient.

Referring physicians desired the opportunity to discuss patient management with their colleagues at the receiving hospitals. They also reported feedback on patient management very critical to collaborating with Level I PICUs. These findings are germane to ensuring optimal care for critically ill children who might need transfer to Level I PICU care and should be incorporated into future guidelines and decision tools created to guide interhospital transfer.

The study findings should be interpreted in light of certain limitations. The nuances inherent in the decision-making process by the referring physicians might not be completely captured in this interview study as the real-time actions of the respondents might differ from their response to the interview. Further, while the study highlighted clinical characteristics that were important to decision-making regarding transfer, the role of non-medical factors including family desires, institutional factors, and peer influence, as reported in prior literature [17], was not explored. It is also not known how much of a role is played by uncertainty regarding patient prognosis in decision making regarding transfer, as highlighted

by prior reports among the elderly [18, 19]. These study limitations highlight areas for future study.

The strengths of the study lie in the breadth of data obtained from referring physicians who practice in level II PICUs daily and are often faced with challenging decisions regarding transfer. The interview process, with participants being asked the same questions, revealed inter-individual variation in the responses without loss of the ability to aggregate the data meaningfully. The study, conducted in a region with a rich mix of Level I and II PICUs, provides insight into the challenges faced by Level II physicians regarding the transfer of children with respiratory failure unresponsive to locally available therapies. The findings could apply to the forty states in the U.S. where there is a combination of Level I and II PICUs and inter-hospital transfer of critically ill children is likely to occur [20], or in other settings where interhospital transfer of children for more advanced respiratory care might occur. While it is likely that the most likely determinant of transfer is the treating physician's clinical judgment, it is unknown how concerns regarding distance to travel, particularly in sparsely resourced settings might influence the decision-making regarding transfer. Future studies are needed to investigate the influence of the population density, resource availability, and availability of PICUs on transfer decision-making.

Transfer of critically ill children with respiratory failure is triggered by poor response to escalation of locally available intensive care modalities. This study provides new insight into decision-making underlying the interhospital transfer of children with respiratory failure from Level II to Level I PICUs. Efforts to enhance optimal transfer of children in severe respiratory failure to Level I PICU care, including future iterations of clinical guidelines and future clinical decision tools, will need to incorporate referring physicians' decision making which is often related to the local availability of various therapeutic modalities and patient response to treatment.

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## Abbreviations

<b>PICU</b>	pediatric intensive care unit
<b>HFOV</b>	high frequency oscillatory ventilation
<b>OI</b>	oxygenation index
<b>ECMO</b>	extracorporeal membrane oxygenation
<b>iNO</b>	inhaled nitric oxide

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# Appendix. Interview Instrument

### Baseline

A 2-year old female child is admitted to the PICU from the emergency department (ED) for management of influenza. In the ED, she was placed on a simple face mask to deliver supplemental oxygen at  $FiO_2$  of 45%, and her oxyhemoglobin saturations were in the low 90s. Three hours after admission to the PICU, she developed significant hypoxia with oxyhemoglobin saturations of 85% on  $FiO_2$  of 1.0 delivered via a non-rebreather mask. She is orotracheally intubated and placed on the ventilator with initial settings on Pressure Control mode of: Frequency 25 breaths/minute, PIP 28  $cmH_2O$ , PEEP 8  $cmH_2O$ ,  $FiO_2$  1.0, and inspiratory time of 0.65 seconds. Arterial and venous catheters are placed. Initial ABG revealed the following values: pH 7.28,  $PCO_2$  54,  $PaO_2$  140, bicarbonate 16.

**In monitoring her response to therapy, which respiratory or oxygenation indices would you observe closely?**

**In your practice, how would you rate the usefulness of the following indices of oxygenation and ventilation in assessing response to therapy in your patients with respiratory failure?**

- |                          |                                 |           |      |      |
|--------------------------|---------------------------------|-----------|------|------|
| <input type="checkbox"/> | Oxygenation Index               | Very good | Fair | Poor |
| <input type="checkbox"/> | $PaO_2/FiO_2$ ratio             | Very good | Fair | Poor |
| <input type="checkbox"/> | $AaDO_2$                        | Very good | Fair | Poor |
| <input type="checkbox"/> | PIP                             | Very good | Fair | Poor |
| <input type="checkbox"/> | $FiO_2$                         | Very good | Fair | Poor |
| <input type="checkbox"/> | Pressure <small>plateau</small> | Very good | Fair | Poor |

**Are there other indices you would consider?**

- How often do you calculate the variables (OI,  $PaO_2/FiO_2$  ratio,  $Aa-DO_2$ , PIP,  $FiO_2$ , Pressure plateau)?
- Which of the indices do you consider most critical to your management of respiratory failure?
- Are there any barriers to retrieving these indices during routine patient care?
- Is there a specific level/value of the indices that gets you concerned for lack of response and need to escalate therapy?
- Is there a duration of ventilation at that OI (and/or other indices) that will get you concerned about possible need to transfer?

### Escalation Point #1

Eight hours later, she is on higher ventilator settings with frequency of 25 breaths/minute, PIP 33  $cmH_2O$ , PEEP 12  $cmH_2O$ , and inspiratory time of 0.8 seconds. Mean airway pressure on the ventilator is 19  $cmH_2O$ , with an oxygenation index of 32. Oxyhemoglobin saturation is 90%. Most recent ABG: pH 7.23,  $PCO_2$  62,  $PaO_2$  59, bicarbonate 14.

**What will you say is the likelihood of the patient turning around clinically. I.e. not require escalation of treatment?**

-----%

**What will be your next step in management?**

- Which therapies will you try now?
- When would you consider such therapies ineffective?
- Would you call to discuss transfer or management options with a Level I PICU?
  - Are there specific indices that will most influence your decision to make the phone call above?

### Escalation Point #2

Several changes are made on the ventilator. Three hours later, her oxyhemoglobin saturation is 88% on these settings: Frequency of 35 breaths/minute, PIP 38 cmH<sub>2</sub>O, PEEP 12 cmH<sub>2</sub>O, inspiratory time of 0.9 seconds, and FiO<sub>2</sub> 0.9. Mean airway pressure on the ventilator is 26 cmH<sub>2</sub>O, with an oxygenation index of 40.

**What will be your next step in management?**

- Are there other therapeutic maneuvers you would consider?
- Would you call to discuss transfer for further support or management options?
- When you call, do the Level I physicians often direct you regarding potential therapeutic maneuvers to attempt?
  - On the average, how do you find such discussions?  
*Helpful Not helpful Varies (dependent on?)*
  - Do these discussions differ based on the specific Level I Hospital, call recipient, etc?

In your practice do you consider a particular timeline for mechanical ventilation during a single PICU stay beyond which you will consider transfer for further care?

- Yes
- No

If yes, how long? ----- hours, ----- days, ----- weeks

**Other potential factors**

During clinical service in the PICU over the past year, how often might the following factors have influenced your decision-making about the possible transfer of a child to a Level I PICU?

	Did not	1-2 times	≥ 3 times
<input type="checkbox"/> Subspecialty staff availability	-----	-----	-----
<input type="checkbox"/> Insurance approval	-----	-----	-----
<input type="checkbox"/> Parental/caregiver desires	-----	-----	-----
<input type="checkbox"/> Availability of specific technology	-----	-----	-----
o ECMO			
o RRT			

What would make the transfer process more efficient at:

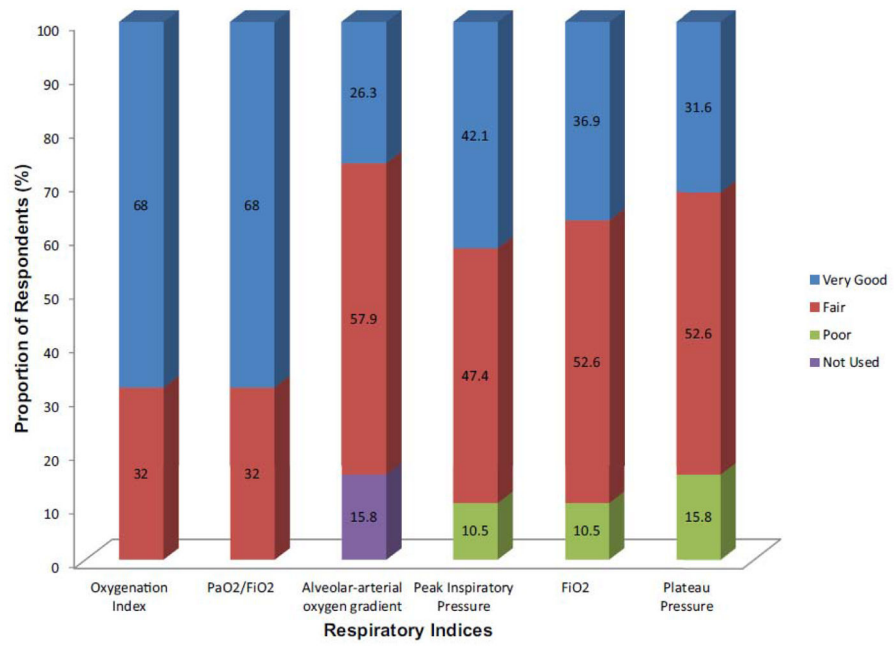
- Your hospital?
- The Level I PICU hospital?

**Final Phase**

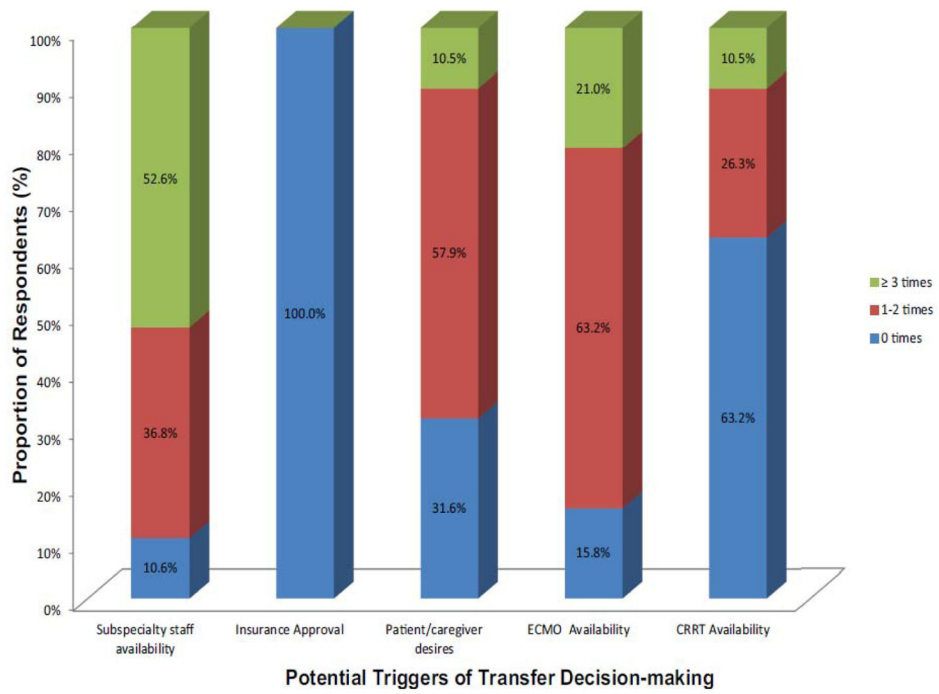
Final questions to ask the participants regarding health system organizational structure and collaboration among PICUs in Michigan:

Overall, to foster collaboration among PICUs in Michigan, how will you rank your interest in the following issues as topics for future discussions?

	Rank
<input type="checkbox"/> Annual meeting of PICU staff from all Michigan PICUs	-----
<input type="checkbox"/> The use of electronic log books in the PICUs	-----
<input type="checkbox"/> Establishment of a real-time electronic database linking all PICUs, with capability for real-time data including patient census, acuity, and potential need for transfer	-----
<input type="checkbox"/> Feedback from Level I PICU physicians regarding the clinical course and outcomes for transferred children	-----
<input type="checkbox"/> Regionalization of pediatric critical care services	-----
<input type="checkbox"/> The use of telemedicine to improve access to PICU services	-----
<input type="checkbox"/> Merits and problems with the current inter-PICU referral system	-----

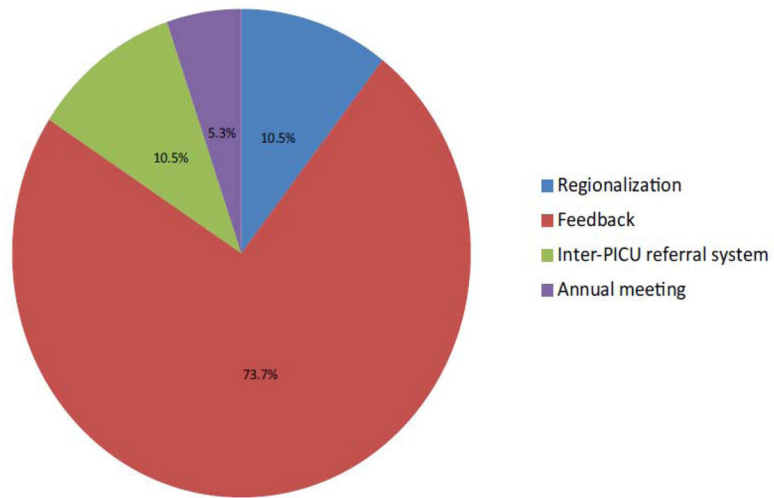


**Figure 1.** Respondents' rating of clinical usefulness of respiratory indices in the management of respiratory failure.



**Figure 2.** Respondents’ rating of the influence of clinical and non-clinical transfer factors on their decision-making in the past year.





**Figure 3.** Top-ranked priority areas for enhanced collaboration between level I and II pediatric intensive care units.

**Table 1**

**Thresholds for Transfer According to the Respondents**

Event	Sample Quotes
<b>Unresponsive to HFOV and/or iNO (n = 11)</b>	<p><i>“If we have settings that are going to injure the patient, or, they don’t start getting better in a relatively short period of time, probably a couple of days, then that’s when we are going to think about sending them.”</i></p> <p><i>“I would probably give the oscillator a try first, okay, and then if that’s not doing anything then give you (receiving hospital) a call.”</i></p> <p><i>“if despite increasing or appropriate kind of support on high frequency, the trend is not toward improvement, with the high frequency, you start with bigger numbers in order to recruit, but those numbers should not stay there and if you are stuck there or having to go even higher, that’s where I would start calling another facility.”</i></p> <p><i>“but by now we are on high frequency and if we are making progress that’s great, sometimes we do, but if it doesn’t look like we are making any progress we probably will initiate a phone call and say “I think this patient may need ECLS, I’m calling you to see what you guys think”</i></p> <p><i>“Still...she’s on the oscillator...right? She’s on very high pressure... ..at this time what I would do I would change to the oscillator number one; number two, have to go to another institution”</i></p> <p><i>“I don’t have nitric oxide therapy here so if I think the patient needs it, then definitely I will be initiating some talks with other institutions. At this point of time, if this was as I said, perfectly healthy prior to this event patient without underlying chronic cardiopulmonary diseases, then I think that I would initiate high frequency ventilation, watch the patient for maybe a few hours. It depends on how the patient tolerates the high frequency vent. And then be in touch with one of the institutions that I routinely send to. “APRV, nitric oxide, oscillator. If this would not work on the oscillator, the phone call for ECMO is made. “If we continue to see a decline; not the immediate decline you might anticipate with the switch, but if within 6 to 12 hours there is no improvement, and/or the child is declining further, we would transfer the child.”</i></p>
<b>Persistent OI &gt;30 (n = 5)</b>	<p><i>“If we were on oscillation and nitric, and we had not achieved reasonable ventilation and oxygenation was still an issue especially if the OI was over 30 at 6 hours after initiation, we will probably be making a serious discussion on referral.”</i></p> <p><i>“I would have to see a pretty dramatic improvement within a couple of hours in terms of you know, either your OI or PaO<sub>2</sub> to FiO<sub>2</sub> ratio improving because I think at this point you are running out of time. You are going to miss your window of where this patient is stable to get her on ECMO before you are on crash ECMO, I think.”</i></p> <p><i>“I would say, if I’m getting to persistent OIs in the 30s, I need to be calling.”</i></p>
<b>Oxygenation not improved over time (n = 3)</b>	<p><i>“I wouldn’t wait long. If, after a few hours of treatment, you know, getting surfactant, high frequency, nitric, if her oxygenation is not improved, I would transfer her.</i></p> <p><i>“If we are still having to increase the settings and her PaO<sub>2</sub> is still so low that her A-a gradient and P-F ratios are getting worse...they are not even staying the same but getting worse.”</i></p> <p><i>“I would go by if the sats are in the 80s after a few hours, I’ll send the patient out.”</i></p> <p><i>“If I hadn’t called yet, I guess if her saturations were staying below 90, if we were on a hundred percent and I couldn’t bring her up anymore. If she started looking like maybe she was going to be having some hemodynamic instability on top of all these; I obviously will be doing things in the meantime but I think her lungs are getting bad enough, quickly enough, that she needs to be somewhere where they have ECMO that people could put her on.”</i></p>

HFOV = High frequency oscillatory ventilation, iNO = inhaled nitric oxide, ECLS = Extracorporeal life support, PIP = Peak inspiratory pressure, PEEP = Positive end expiratory pressure, APRV = Airway pressure release ventilation, ECMO = Extracorporeal membrane oxygenation, OI = Oxygenation index, A-a gradient = Alveolar-arterial gradient, P/F = Partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) divided by FiO<sub>2</sub> Fraction of inspired oxygen concentration), SPO<sub>2</sub> = Peripheral oxygen saturation.

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**Table 2**

## Perceptions regarding the interhospital transfer process

Event	Sample Quotes
<b>Single phone call desired (n = 14)</b>	<p><i>"I think particularly with ECMO, usually I talk to the fellow, and I talk to the attending, and I have to talk to a perfusionist, so there's a few people that you have to talk to that is sometimes cumbersome."</i></p> <p><i>"It isn't as one-stop shopping as I would like"</i></p> <p><i>"I have called and asked to talk to the attending just so I can get some ideas, and it's really good to have somebody who is also an attending to bounce the ideas off of and I've gotten good ideas before like that and I like that."</i></p> <p><i>"Number 1; let me talk directly to the doctor who is actually going to be receiving the patient. That's probably the biggest thing because there is no amount of written or sign out stuff that can substitute for it."</i></p> <p><i>"When I call another hospital, I ask to speak to the attending rather than a fellow. I will clearly explain to the fellow what I'm dealing with, but I want to talk to the attending, and say "look, what would you do differently, right now?"</i></p>
<b>Process is good (n = 5)</b>	<p><i>"In general, I'm satisfied with the process that we have now and in the past when we were transferring quite a sick patient, we had a situation where the fellow actually came with the transport team. So, at this point, I think the process is....all that I have to do is a phone call and prepare a discharge summary."</i></p> <p><i>"So, everything from the communication directly with the PICU, and communication about bed availability, it's been good. That's at least my experience."</i></p> <p><i>"Sometimes I've felt maybe discussion at an attending-to-attending level may expedite that process, particularly if the attending is not in-house at that point in time. But I would say that at least in the recent past when I've talked to your fellows, the response ....the return has been pretty quick, so, it hasn't delayed the process of decision-making."</i></p>

ECMO = Extracorporeal membrane oxygenation, PICU = Pediatric intensive care unit.