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Enhancing Care for Retinopathy of Prematurity Patients through Better Logistic Planning, Process Mapping, and Telemedicine-Driven Interventions

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Abstract

Retinopathy of Prematurity (ROP) is a serious condition that disrupts the development of retinal blood vessels in premature infants, posing a significant risk of permanent blindness if not promptly diagnosed and treated. A critical component of managing ROP is ensuring the safe, timely, and efficient transport of neonates to specialized care facilities equipped to deliver the necessary interventions. Despite the importance of this process, to the best of our knowledge, no prior studies have explored process mapping within this specific context. This paper aims to evaluate neonatal transfer practices from a process perspective, identify opportunities for quality improvement, and propose targeted telemedicine interventions to enhance the transfer process. To achieve this, we used Business Process Model and Notation (BPMN) to map and analyze the existing workflows systematically. The findings of this study include a detailed examination of current practices. Based on these insights, we developed targeted telemedicine interventions designed to optimize care delivery for this vulnerable population. These interventions aim to improve coordination, reduce delays, and ensure timely access to specialized care. The results of this study have the potential to lay the foundation for the development of necessary laws and regulations governing neonatal transfer services in the country. Furthermore, this paper seeks to foster collaboration among healthcare stakeholders, inform evidence-based policy-making, and promote standardization in clinical workflows. Ultimately, these efforts are expected to lead to improved patient outcomes, enhanced operational efficiency, and a more robust neonatal care system.

Keywords: Business process model and notation, Telemedicine, Process mapping, Retinopathy of prematurity, Neonatal transfer.

1 | Introduction

Retinopathy of Prematurity (ROP) is a condition affecting the retinal blood vessels of premature infants, potentially leading to blindness if not properly managed. The transportation of neonates requiring specialized

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care for ROP is a critical aspect of their treatment, ensuring timely access to necessary interventions. Transporting premature infants, especially those at risk for ROP, presents significant challenges due to their vulnerability during transit. Transport teams need to be adept at monitoring and managing the specific needs of these neonates, with a critical focus on maintaining appropriate oxygen levels to prevent exacerbating ROP.

As far as we know, no studies have specifically focused on the neonatal transfer process for ROP, nor have there been any improvement initiatives targeting this particular type of transfer. Therefore, one key approach that serves as a fundamental step for any improvement initiative is process modeling [1], [2].

The importance of this study cannot be overstated, as untreated ROP can lead to severe and irreversible complications, including retinal detachment, blindness, strabismus, refractive errors, cataracts, glaucoma, and loss of peripheral vision. These conditions profoundly impact a patient's quality of life, limiting their ability to engage in daily activities and achieve their full potential [3]. Furthermore, the long-term health consequences of ROP impose high direct and indirect costs, encompassing healthcare expenditures, rehabilitation needs, and productivity losses. These factors collectively contribute to a substantial socioeconomic burden that extends over the first four decades of life [4]. Given these far-reaching implications, the safe and efficient transportation of neonates requiring specialized ROP care emerges as a critical component of their treatment. Ensuring timely access to necessary interventions not only mitigates the risk of lifelong disabilities but also alleviates the broader economic and societal costs associated with untreated ROP.

A narrative review of ROP management emphasizes the importance of early screening and intervention to improve outcomes for infants with ROP. Advances in screening techniques have improved outcomes for infants with ROP; however, ongoing research is needed to optimize management strategies and reduce the burden of this condition [5]. Additionally, a study of ROP management in a Polish cohort highlights the importance of timely, appropriate treatment paradigms in improving visual outcomes for affected infants [6].

Studies have indicated that both hyperoxia and fluctuations in oxygen saturation can influence the development and severity of ROP. Therefore, meticulous control of oxygen delivery during transport is crucial to mitigate the risk of ROP progression [7]. A study explored integrating bedside ROP screening with telemedicine within a neonatal transport framework. This approach aimed to enhance early detection and treatment of ROP, particularly in settings where immediate access to pediatric ophthalmologists is limited. The study found that such integration could be cost-effective, improving outcomes for premature infants by facilitating timely interventions during transport [8].

Neonates with ROP can be classified into categories based on the severity of their condition and the need for transportation to specialized care. *Table 1* presents a classification system based on the International Classification of ROP, Third Edition, to prioritize transport decisions based on clinical presentation and risk of progression [9].

Table 1. Classification of neonates with retinopathy of prematurity based on transportation needs.

Emergency Transportation Required (Highest Priority)		
These neonates require immediate transport to a specialized center for urgent intervention, as their condition poses a high risk of permanent vision loss without timely treatment.	Aggressive Posterior ROP (AP-ROP)	A severe, rapidly progressing form of ROP with a high risk of blindness. Requires immediate intervention to prevent retinal detachment.
	Severe Stage 3 ROP	Cases with a high likelihood of rapid progression. Requires urgent treatment such as laser therapy, anti-VEGF injections, or surgery.
	Stage 4 or 5 ROP (Partial or Total Retinal Detachment)	Advanced ROP with significant risk of permanent vision impairment. Requires urgent surgical intervention (e.g., vitrectomy or scleral buckling).

Table 1. Continued.

Semi-Urgent Transportation (High Priority)		
Neonates who need transportation within a few days to a specialized center for close monitoring and potential treatment.	Moderate Stage 3 ROP	Increased risk of progression, but does not require immediate intervention. Needs specialist evaluation and possible treatment within a few days.
	Stage 2 ROP with signs of worsening disease	Requires close follow-up and potential intervention soon.
Scheduled Transportation for Screening and Monitoring (Moderate Priority)		
Neonates in this category do not require immediate treatment but may need transportation for specialist evaluation, telemedicine assessment, or continued monitoring.	Mild to Moderate Stage 1 or 2 ROP	Requires regular screening but is not at immediate risk of progression.
	Preterm neonates with risk factors for ROP but no current signs of disease	Requires ophthalmologic screening at appropriate intervals.
No Need for Transportation (Can Be Managed Locally)		
These neonates can be monitored and managed in the local hospital without the need for transportation.	Mild Stage 1 ROP in the peripheral retina	Usually self-resolving and does not require treatment. Regular local follow-up is sufficient.
	Fully Regressed ROP	No active disease; requires long-term follow-up for visual development, but no urgent transport.

Logistically, neonatal transport is a highly critical and sensitive process, especially in cases involving ROP. The inherent fragility of neonates, combined with the urgency of their medical condition, necessitates careful planning and precise execution. However, the challenge is compounded by limited resources, including a shortage of skilled staff, insufficient equipment, and communication barriers, all of which significantly increase the complexity of this process. These constraints add another layer of difficulty to an already high-stakes environment. By strategically implementing advanced logistics fleet management practices alongside telemedicine-driven interventions, we can optimize resource allocation, minimize delays, and enhance the overall efficiency of neonatal transport systems, ultimately improving outcomes for these vulnerable patients.

Currently, there is no standardized approach to neonatal transport for ROP across various provinces in Iran. The goal of this study is to thoroughly examine the inter-hospital workflows involved in the care of neonates affected by ROP. By mapping and analyzing the "as-is" processes at the organizational level, this research aims to highlight current practices, identify inefficiencies, and propose targeted telemedicine interventions to address these gaps.

The results of this study can help lay the foundation for laws and regulations governing neonatal transfer services in the country. Given the lack of a unified approach across provinces, the insights presented in this paper have the potential to foster collaboration among healthcare stakeholders, inform evidence-based policy-making, and promote standardization in clinical workflows. Ultimately, these efforts aim to improve patient care, enhance operational efficiency, and ensure equitable access to life-saving interventions for neonates with ROP.

2 | Method

This section outlines the research methods used to investigate and analyze the neonatal transport process for ROP in Iran. Given the complexity of neonatal transport systems and the multidisciplinary nature of the research, a combination of process modeling, data collection, and collaborative analysis was employed. The goal was to thoroughly map existing workflows, identify inefficiencies, and propose improvements to enhance the overall transport process. The following subsections describe the study design, the process modeling approach, data collection methods, and the analysis and validation procedures utilized in this study.

2.1 | Study Design and Team Composition

A multidisciplinary team was assembled to conduct this study, comprising industrial engineers from Qotbe Salamat at Tarbiat Modares University and healthcare professionals.

This collaborative approach ensured a comprehensive understanding of both the technical and clinical aspects of the transport processes.

2.2 | Process Modeling Approach

To model the transfer process, we employed Business Process Model and Notation (BPMN), a widely accepted and recognized framework in the enterprise market. BPMN was selected for its ability to effectively represent both basic and complex processes while maintaining simplicity, transparency, and comprehensibility for all stakeholders, including those in the healthcare field [10].

2.3 | Data Collection Methods

The process was identified and mapped using a combination of data collection methods, including but not limited to:

I. Interviews: conducted with key stakeholders involved in neonatal transport to gather firsthand insights into current practices.

II. Brainstorming sessions: facilitated collaborative discussions among team members to identify critical steps, inefficiencies, and potential improvements in the process.

III. Review of existing documentation: policy documents, manuals, and guidelines related to neonatal transfer were analyzed, with a particular focus on neonatal transfer policy documents from Tabriz province.

3 | Result

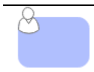
Using BPMN, we successfully visualized the inter-hospital transfer processes for critical groups of ROP patients who require meticulous care in Tabriz province. The BPMN diagrams, as shown in *Fig. 1*, provided a clear, structured representation of the workflows, highlighting key steps, decision points, and stakeholder interactions.

To aid readers in understanding the BPMN diagrams, Table 2 provides a brief description of BPMN terminology and instructions for interpreting them. It includes explanations of symbols, flows, and subprocesses used in the modeling process. To enhance clarity and simplify the presentation of complex workflows, we incorporated subprocesses within the BPMN diagrams. These subprocesses are denoted by a plus sign (+) within the task boxes, providing a more organized, hierarchical representation of the transfer processes. This approach ensured that the diagrams remained accessible and comprehensible to all stakeholders, including those without prior expertise in process modeling.

Table 2. Brief guide to business process model and notation terminology.

Symbol	Name	Description
	Tasks	Rectangles represent individual tasks or activities within the process.
	Subprocesses	Rectangles with a plus sign (+) denote subprocesses, which contain their own detailed process diagrams.

Table 2. Continued.

Symbol	Name	Description
	User tasks	Rectangles with a human icon indicate User Tasks, where a human performer carries out the task with the assistance of a software application.
	Sequence flow	Represented by a solid line, this shows the order in which activities are performed within a process.
	Message flow	Represented by a dashed line with an open arrowhead, this illustrates the flow of messages between two separate process participants.
~	Ad hoc marker	This marker indicates that the sequence of activities is flexible. In such cases, activities can be performed in any order at the discretion of the users.
	Messages	Envelope icons represent messages or data being sent or received.
	Exclusive gateway	This gateway models decision points in a process where the flow diverges into two or more mutually exclusive paths.
	Parallel gateway	It is used to model points in the process where the flow splits into multiple parallel paths that are executed simultaneously.

The figure consists of five lanes that represent key inter-organizational stakeholders: the upper lane is the doctor at the referring hospital, the second lane represents the birth parents of the sick child, the third lane is the Medical Coordination and Monitoring Center (MCMC) staff, the fourth lane is the transport team, and the last lane is the staff at the destination hospital. The process starts in the upper-left corner at the referring hospital. The figure is structured into five distinct lanes, each representing a key inter-organizational stakeholder involved in the neonatal transfer process:

I. Doctor at the referring hospital: the top lane represents the physician at the referring hospital, who initiates the transfer process by assessing the infant's condition and determining the need for specialized care.

II. Birth parents of the sick child: the second lane highlights the role of the infant's parents, who are actively involved in the decision-making process and accompany the child during transfer, as mandated by guidelines.

III. MCMC staff: the third lane represents the MCMC staff, who facilitate communication, coordinate resources, and ensure the transfer is organized and efficient.

IV. Transport team: the fourth lane depicts the transport team, responsible for safely transferring the infant while providing continuous medical care and monitoring during transit.

V. Staff at the destination hospital: the final lane represents the receiving hospital's staff, who prepare for the infant's arrival and provide immediate care upon handover

The process begins in the upper-left corner of the diagram, representing the initial steps taken at the referring hospital. It flows sequentially across the lanes to illustrate the collaborative efforts of all stakeholders involved in the transfer. This visual representation ensures clarity and highlights the interconnected roles of each participant in the neonatal transfer process.

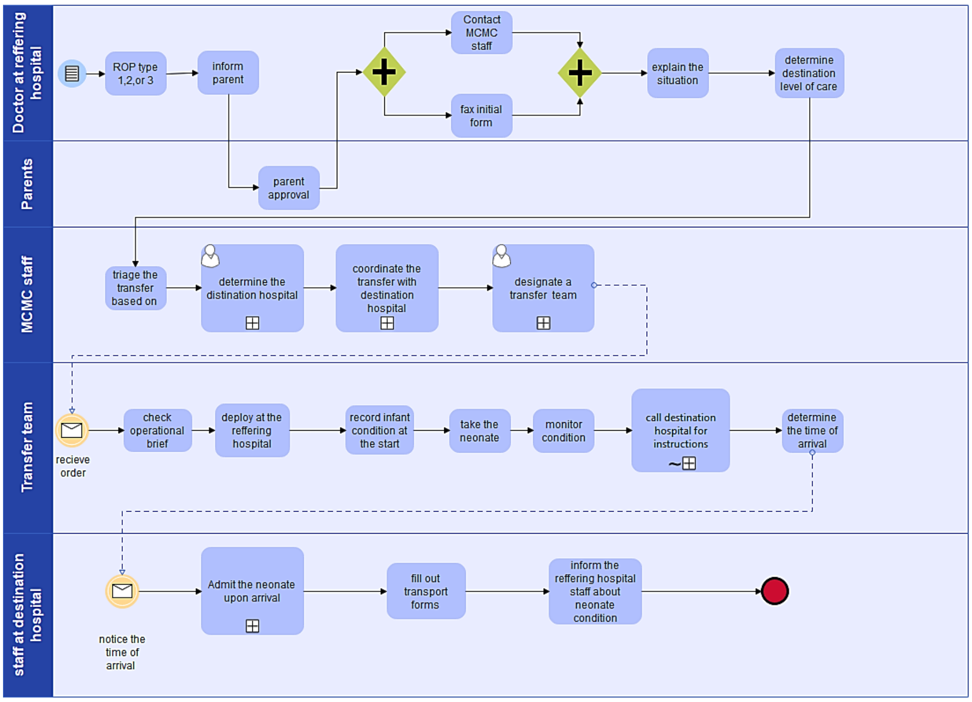


Fig. 1. Interorganizational transfer of retinopathy of prematurity patients.

3.1 | Analysis

Below are several observations and recommendations stemming from this BPMN diagram. These insights focus on streamlining workflows, improving communication, and addressing potential bottlenecks to enhance both clinical care and operational efficiency:

Centralized Coordination (medical coordination and monitoring center)

Triage clarity: the MCMC staff appear responsible for triaging the infant based on ROP type and urgency, then determining the appropriate destination hospital. It is a pivotal role that can reduce delays if clear, evidence-based triage criteria are in place (e.g., standardized checklists or protocols to quickly assess risk).

Real-time communication: the use of faxed forms suggests delays in information exchange. Replacing or supplementing fax with electronic data-sharing platforms (e.g., secure messaging, telemedicine portals) can accelerate triage and reduce the risk of misplaced or incomplete forms.

Parent approval and consent

Informed consent process: parents must approve the referral before it is finalized. Streamlining how parents are informed (e.g., standardized educational materials, teleconsultations with neonatologists) can expedite consent.

Minimizing bottlenecks: if parents have questions or concerns, this step can become a bottleneck. Providing easily understandable digital or printed materials about ROP and transfer rationale can help shorten the approval process.

Transfer team deployment

Operational brief: The diagram shows a step in which the transfer team reviews its operational brief before leaving. Ensuring this brief includes up-to-date, relevant clinical details (e.g., infant's vitals, infection status, any special equipment needed) is crucial. Automated updates or a shared online workspace can make these briefs more timely and accurate.

In-transit clinical data capture

Condition recording: the process explicitly includes recording the infant's condition at the start and en route. It is invaluable for patient safety and quality improvement. However, capturing data in real time (e.g., via a tablet or a secure mobile application) can reduce documentation errors and enable immediate updates to both the MCMC and the receiving hospital.

Telemedicine potential: telemonitoring (e.g., continuous vital sign transmission) would enable specialists to supervise critical transports and guide the team if urgent interventions are needed. It also helps the receiving hospital prepare in advance.

Destination hospital preparedness

Advance notice: the team calls the destination hospital and determines the Estimated Time of Arrival (ETA). Streamlining this into an automated notification system (e.g., SMS alerts, push notifications) can help the receiving team allocate staff, equipment, and Neonatal Intensive Care Unit (NICU) beds more effectively.

Admission workflow: the diagram shows that the neonate is admitted upon arrival, forms are completed, and the referring hospital is notified. Automating part of this admission workflow (e.g., prefilling transport data and sending electronic health records) can reduce manual tasks and speed the start of treatment.

Post-transfer communication

Outcome reporting: the final step indicates that the referring hospital is notified about the neonate's condition. A more formalized feedback loop—where outcomes, any complications, and time metrics (e.g., door-to-door interval) are documented—can help identify opportunities to refine the process.

Quality improvement: aggregating transport metrics (e.g., transfer time, complications en route) allows hospitals and MCMC to conduct periodic reviews, compare performance against benchmarks, and adjust protocols for continuous improvement.

Potential bottlenecks and risks

Reliance on manual steps: the diagram includes steps such as faxing forms and multiple handoffs, which may be prone to human error or delay. Automation, form standardization, and real-time digital communication can mitigate these risks.

Resource constraints: Depending on the availability of specialized transfer teams and vehicles, wait times may vary. A scheduling or dispatch system that matches resource availability with infant urgency would improve responsiveness.

Scalability and standardization

Protocol uniformity: standardizing these BPMN steps across all referring and receiving hospitals can reduce variability and confusion—especially important in a nationwide system where multiple facilities might follow slightly different procedures.

Scaling telemedicine: as telemedicine capacity grows, incorporating remote consultations and real-time data sharing into this BPMN will further optimize transfers for ROP and other high-risk neonatal conditions.

3.2 | Applications of Telemedicine in Retinopathy of Prematurity Transport

After documenting the neonatal transfer process for ROP, we explored strategies to enhance this process through telemedicine interventions. The findings and recommendations derived from this analysis are elaborated below. By leveraging telemedicine, we identified opportunities to streamline communication, optimize resource allocation, and enhance the overall efficiency and safety of neonatal transfers.

Real-time monitoring of vital signs

Clinical benefit: telemedicine enables continuous monitoring of an infant's vital signs—such as heart rate, oxygen saturation, and respiratory status—during transport. It allows transport teams to detect any critical changes in the infant's condition and provide immediate intervention if necessary, all while maintaining communication with specialists for guidance.

Logistical perspective: real-time data transmission reduces the need for additional specialized personnel on every transport, as clinicians can remotely supervise multiple cases simultaneously. Additionally, continuous monitoring helps dispatch centers dynamically allocate resources (e.g., transport vehicles, equipment) based on the baby's evolving condition, leading to more efficient scheduling and reduced turnaround times.

Remote consultation for immediate guidance

Clinical benefit: Specialists in neonatology and ophthalmology can offer real-time remote consultations during transport, providing expert advice on immediate actions based on the infant's clinical presentation. It ensures that transport teams make informed decisions regarding the urgency of the transport or any required interventions en route.

Logistical perspective: remote specialist access minimizes service duplication and prevents unnecessary deployments of multiple teams or equipment. By rapidly clarifying clinical urgency, transport coordinators can prioritize and allocate critical resources (vehicles, staff) more effectively, reducing delays and enhancing overall operational flow.

Transmission of retinal images for remote evaluation

Clinical benefit: telemedicine platforms can transmit high-quality retinal images to specialists, enabling them to remotely assess ROP severity and provide recommendations for urgent treatments, such as laser therapy or medication administration, during transport. It helps prioritize the transport of higher-risk infants, improving clinical outcomes.

Logistical perspective: immediate specialist feedback on the severity of ROP allows transport services to quickly determine if an urgent transfer is required and, if so, to mobilize the most suitable transport modality (ambulance vs. air transport). Early prioritization prevents resource wastage on less critical cases and ensures that the highest-risk infants receive prompt attention, optimizing fleet and staff utilization.

Enhancing coordination between teams

Clinical benefit: telemedicine improves communication and coordination among transport teams, NICUs, and specialists. With continuous updates from all involved parties, clinicians can ensure the right resources are prepared in advance, reducing transport delays and improving preparedness for immediate care upon arrival.

Logistical perspective: centralized communication platforms help streamline scheduling by alerting all relevant units about incoming cases in real time. It reduces bottlenecks—for instance, waiting for equipment or staff handovers—and ensures NICUs have the appropriate personnel, supplies, and space ready. Consequently, transport cycles are shortened, thereby improving overall throughput.

Remote monitoring of oxygen therapy and ventilation support

Clinical benefit: In cases where neonates require respiratory support, telemedicine enables continuous remote monitoring of oxygen levels and ventilatory parameters, ensuring the infant receives appropriate respiratory care throughout transport. Adjustments to therapy can be made in real-time, minimizing the risk of complications.

Logistical perspective: remote supervision of respiratory parameters means fewer specialized respiratory therapists need to be physically present on each transport, allowing for more flexible staff allocation across multiple calls. Real-time monitoring also ensures that specialized equipment (such as advanced ventilators or backup oxygen supplies) is deployed exactly when and where it's needed, avoiding overstocking or shortages.

Data integration for holistic decision-making

Clinical benefit: telemedicine enables the integration of various patient data streams, including retinal images, vital signs, and medical histories, into a single platform. This comprehensive data allows specialists to make holistic decisions about the infant's care during transport, ensuring that all aspects of the infant's condition are considered and addressed.

Logistical perspective: a centralized data repository supports administrative and operational planning by providing transport coordinators with real-time visibility into each infant's status. It reduces redundant communication channels and helps planners allocate vehicles, routes, and staff more effectively. Having a single source of truth minimizes coordination errors and scheduling conflicts.

Predictive analytics for transport prioritization

Clinical benefit: By leveraging telemedicine systems with predictive analytics capabilities, specialists can analyze historical and real-time data to assess the risk of ROP progression and predict the urgency of transport. It can aid in prioritizing cases, ensuring that those with the highest risk are transported first, reducing delays for critical cases.

Logistical perspective: predictive analytics helps transport coordinators dynamically adjust transport schedules and routing based on risk severity, leading to more efficient use of limited transport assets. High-risk cases can be flagged automatically, prompting immediate resource mobilization, while lower-priority transfers can be rescheduled or combined to optimize trip planning and reduce overall costs.

Educational support for transport teams

Clinical benefit: Telemedicine can also be used to provide real-time educational support to transport teams, particularly in less experienced or rural areas. By connecting to experienced specialists, the transport team can receive guidance on handling complex ROP cases, improving their skills and confidence in managing these infants during transport.

Logistical perspective: remote training modules and just-in-time learning reduce the need for frequent in-person sessions, thereby lowering travel expenses and addressing scheduling challenges. A well-trained, more confident transport workforce can manage a wider range of clinical scenarios independently, increasing the overall capacity of the transport system and minimizing the need for repeated or escalated transfers

4 | Discussion

This study utilized BPMN to map and analyze the neonatal transfer process for ROP patients in Tabriz, Iran. To the best of our knowledge, no prior study has specifically focused on neonatal transfer processes for ROP in this context, nor has any exploration of initiatives to improve these processes been conducted. Therefore, process modeling—a fundamental step for any improvement initiative—provides a systematic framework to enhance the overall quality of care [1], [2].

This detailed process mapping enabled us to identify key points where telemedicine interventions could improve efficiency, reduce delays, and enhance patient outcomes. By analyzing the workflow, we detected critical points where telemedicine solutions could be effectively implemented to optimize coordination, decision-making, and resource utilization during transport.

Prior studies have explored the use of telemedicine in neonatal transport with varying focuses. Berrocal et al. [11] examined how real-time monitoring and consultation with specialists can improve decision-making and outcomes, findings that align with ours on the importance of continuous monitoring and remote expertise. However, our study expands upon this by detailing multiple targeted applications that enhance coordination, data integration, and predictive analytics for transport prioritization [11].

Kovács et al. [8] examined integrating bedside ROP screening with telemedicine during neonatal transport to facilitate early detection and intervention. Our study expands on this by incorporating telemedicine for screening and optimizing transport logistics, ensuring that high-risk infants receive specialized care without unnecessary delays [8].

A related initiative in Hungary focused on training neonatal transport nurses to conduct initial ROP screenings to mitigate the shortage of ophthalmologists [12]. While this approach addresses workforce limitations, our study suggests a more scalable model in which transport teams receive continuous remote support from specialists rather than relying solely on in-person screening by trained nurses.

Haynes et al. [13] explored the use of telemedicine interventions to reduce inter-hospital transfers, demonstrating that remote consultations and real-time monitoring can minimize the need for patient transfers between facilities. Similarly, Hayden et al. [14] investigated the role of telemedicine in reducing intra-hospital neonatal transfers, highlighting its potential to streamline workflows and improve care coordination within a single hospital. Together, these studies underscore the versatility of telemedicine in optimizing neonatal transport processes, whether across facilities or within a hospital

4.1 | Future Studies

By integrating telemedicine-driven solutions into neonatal transport, healthcare providers can create a more efficient, data-driven system that enables timely, well-informed interventions. Future studies should focus on implementing these interventions in real-world neonatal transport settings to assess their effectiveness in reducing transport-associated delays and improving clinical outcomes. Additionally, cost-benefit analyses should be conducted to determine the financial feasibility of scaling these telemedicine applications across various healthcare systems.

Moreover, it is essential to expand the scope of research to include other neonates with specific needs during transport. While this study focused on ROP, there are numerous other conditions—such as congenital heart defects, severe respiratory distress, or neurological disorders—that require specialized and often urgent transport. Identifying and mapping the unique challenges associated with these conditions can provide a more comprehensive understanding of neonatal transport systems.

5 | Conclusion

The effectiveness of any medical treatment hinges on efficient time management, and transferring neonates with ROP is no exception when it comes to delivering urgent medical care. Neonatal transfer is inherently a complex system that requires the simultaneous management of numerous interactions and operations. It involves multiple stakeholders performing diverse activities, all of which demand a high level of coordination and organization. As far as we know, no prior study has specifically focused on the neonatal transfer process for ROP, nor has there been an exploration of initiatives to improve it.

By systematically mapping and analyzing the current workflows through process modeling, this study provides a clear understanding of existing practices and identifies key areas for improvement. Our findings suggest that, from a logistical standpoint, telemedicine not only enhances transport efficiency but also contributes to long-term improvements in neonatal care by ensuring that infants receive timely and expert-guided interventions. The integration of telemedicine enables real-time monitoring, remote consultations, and data-driven decision-making, all of which are critical for optimizing resource allocation and reducing delays in neonatal transport.

References

[1] Gabryelczyk, R., Sipior, J. C., & Biernikowicz, A. (2024). Motivations to adopt BPM in view of digital transformation. *Information systems management*, *41*(4), 340–356. https://doi.org/10.1080/10580530.2022.2163324

[2] Marsinyach Ros, I., Sanchez García, L., Sanchez Torres, A., Mosqueda Peña, R., Pérez Grande, M. del C., Rodríguez Castaño, M. J., … ., & Sánchez Luna, M. (2020). Evaluation of specific quality metrics to assess the performance of a specialised newborn transport programme. *European journal of pediatrics*, *179*(6), 919–928. https://doi.org/10.1007/s00431-020-03573-z

[3] Hong, E. H., Shin, Y. U., Bae, G. H., Choi, Y. J., Ahn, S. J., Kim, I., & Cho, H. (2022). Ophthalmic complications in retinopathy of prematurity in the first decade of life in Korea using the national health insurance database. *Scientific reports*, *12*(1), 911. https://doi.org/10.1038/s41598-021-04616-7

[4] Dave, H. B., Gordillo, L., Yang, Z., Zhang, M. S., Hubbard, G. B., & Olsen, T. W. (2012). The societal burden of blindness secondary to retinopathy of prematurity in Lima, Peru. *American journal of ophthalmology*, *154*(4), 750–755. https://doi.org/10.1016/j.ajo.2012.04.003

[5] Bishnoi, K., Prasad, R., Upadhyay, T., & Mathurkar, S. (2024). A narrative review on managing retinopathy of prematurity: Insights into pathogenesis, screening, and treatment strategies. *Cureus*, *16*(3), 1–9. https://doi.org/10.7759/cureus.56168

[6] Chmielarz-Czarnocińska, A., Pawlak, M., Szpecht, D., Choręziak, A., Szymankiewicz-Bręborowicz, M., & Gotz-Więckowska, A. (2021). Management of retinopathy of prematurity (ROP) in a Polish cohort of infants. *Scientific reports*, *11*(1), 4522. https://doi.org/10.1038/s41598-021-83985-5

[7] Hartnett, M. E., & Lane, R. H. (2013). Effects of oxygen on the development and severity of retinopathy of prematurity. *Journal of American association for pediatric ophthalmology and strabismus*, *17*(3), 229–234. https://doi.org/10.1016/j.jaapos.2012.12.155

[8] Kovács, G., Somogyvári, Z., Maka, E., & Nagyjánosi, L. (2017). Bedside ROP screening and telemedicine interpretation integrated to a neonatal transport system: Economic aspects and return on investment analysis. *Early human development*, *106–107*, 1–5. https://doi.org/10.1016/j.earlhumdev.2017.01.007

[9] Chiang, M. F., Quinn, G. E., Fielder, A. R., Ostmo, S. R., Paul Chan, R. V, Berrocal, A., … ., & Zin, A. (2021). International classification of retinopathy of prematurity, third edition. *Ophthalmology*, *128*(10), e51–e68. https://doi.org/10.1016/j.ophtha.2021.05.031

[10] Rolón, E., Garcia, F., Ruiz, F., Piattini, M., Calahorra, L., Garcia-Rojo, M., & Martin, R. (2008). Process modeling of the health sector using BPMN: A case study. *Proceedings of the first international conference on health informatics* (pp. 173-178). https://www.researchgate.net/publication/221334166

[11] Berrocal, A. M., Fan, K. C., Al-Khersan, H., Negron, C. I., & Murray, T. (2022). Retinopathy of prematurity: Advances in the screening and treatment of retinopathy of prematurity using a single center approach. *American journal of ophthalmology*, *233*, 189–215. https://doi.org/10.1016/j.ajo.2021.07.016

[12] Somogyvári, Z., Maka, E., Németh, J., & Nagy, Z. Z. (2019). Training hungarian neonatal transport nurses in screening for retinopathy of prematurity with telemedicine. *Developments in health sciences*, *2*(3), 65–71. https://doi.org/10.1556/2066.2.2019.011

[13] Haynes, S. C., Dharmar, M., Hill, B. C., Hoffman, K. R., Donohue, L. T., Kuhn-Riordon, K. M., … ., & Marcin, J. P. (2020). The impact of telemedicine on transfer rates of newborns at rural community hospitals. *Academic pediatrics*, *20*(5), 636–641. https://doi.org/10.1016/j.acap.2020.02.013

[14] Hayden, E. M., Boggs, K. M., Espinola, J. A., Camargo, C. A., & Zachrison, K. S. (2020). Telemedicine facilitation of transfer coordination from emergency departments. *Annals of emergency medicine*, *76*(5), 602–608. https://doi.org/10.1016/j.annemergmed.2020.04.027

Appendix

BPMN XML for Mapping the Transfer Process


```
<?xml version="1.0" encoding="UTF-8"?>
<bpmn:definitions xmlns:bpmn="http://www.omg.org/spec/BPMN/20100524/MODEL"
xmlns:bpmndi="http://www.omg.org/spec/BPMN/20100524/DI"
xmlns:di="http://www.omg.org/spec/DD/20100524/DI"
xmlns:dc="http://www.omg.org/spec/DD/20100524/DC"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" id="Definitions_1"
targetNamespace="http://bpmn.io/schema/bpmn">
 <bpmn:process id="NeonatalTransferProcess" name="Neonatal Transfer Process" isExecutable="true">

  <!-- Start Event: Assess Condition and Need for Transfer -->
  <bpmn:startEvent id="StartEvent_AssessCondition" name="Assess Condition and Need for Transfer">
   <bpmn:outgoing>SequenceFlow_1</bpmn:outgoing>
  </bpmn:startEvent>

  <!-- Task: Doctor Assesses Condition -->
  <bpmn:task id="Task_DoctorAssessesCondition" name="Doctor Assesses Condition">
   <bpmn:incoming>SequenceFlow_1</bpmn:incoming>
   <bpmn:outgoing>SequenceFlow_2</bpmn:outgoing>
  </bpmn:task>

  <!-- Task: Doctor Explains Condition to Parents -->
  <bpmn:task id="Task_DoctorExplainsCondition" name="Doctor Explains Condition to Parents">
   <bpmn:incoming>SequenceFlow_2</bpmn:incoming>
   <bpmn:outgoing>SequenceFlow_3</bpmn:outgoing>
  </bpmn:task>

  <!-- Gateway: Parent Approval -->
  <bpmn:exclusiveGateway id="Gateway_ParentApproval" name="Parent Approval">
   <bpmn:incoming>SequenceFlow_3</bpmn:incoming>
   <bpmn:outgoing>SequenceFlow_4</bpmn:outgoing>
   <bpmn:outgoing>SequenceFlow_5</bpmn:outgoing>
  </bpmn:exclusiveGateway>
```

```
<!-- Task: End Process if Parents Reject Transfer -->
<bpmn:task id="Task_EndProcessNoApproval" name="End Process (No Approval)">
  <bpmn:incoming>SequenceFlow_5</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_6</bpmn:outgoing>
</bpmn:task>

<!-- Task: Coordinate transfer -->
<bpmn:task id="Task_CoordinateTransfer" name="Coordinate Transfer (Call MCMC Staff)">
  <bpmn:incoming>SequenceFlow_4</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_7</bpmn:outgoing>
</bpmn:task>

<!-- Task: Send Form to MCMC Staff -->
<bpmn:task id="Task_DoctorSendsForm" name="Doctor Sends Form to MCMC Staff">
  <bpmn:incoming>SequenceFlow_7</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_8</bpmn:outgoing>
</bpmn:task>

<!-- Task: Select Hospital Level -->
<bpmn: task id="Task_DoctorSelectsHospitalLevel" name="Doctor Selects Hospital Level (Level 2, 3)">
  <bpmn:incoming>SequenceFlow_8</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_9</bpmn:outgoing>
</bpmn:task>

<!-- Task: Inform MCMC Staff about the level -->
<bpmn:task id="Task_InformMCMCLevel" name="Doctor Informs MCMC Staff about Level">
  <bpmn:incoming>SequenceFlow_9</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_10</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Grades the Infant's Transfer -->
<bpmn:task id="Task_MCMCGradesTransfer" name="MCMC Staff Grades Infant Transfer">
  <bpmn:incoming>SequenceFlow_10</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_11</bpmn:outgoing>
</bpmn:task>
```

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<!-- Task: MCMC Staff Determines Destination Hospital -->
<bpmn:task id="Task_MCMCDeterminesDestination" name="MCMC Staff Determines Destination Hospital">
  <bpmn:incoming>SequenceFlow_11</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_12</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Informs Doctor at Destination Hospital -->
<bpmn:task id="Task_MCMCInformsDoctor" name="MCMC Staff Informs Doctor at Destination">
  <bpmn:incoming>SequenceFlow_12</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_13</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Triages Transfer -->
<bpmn:task id="Task_MCMCStaffTriagesTransfer" name="MCMC Staff Triages Neonate Transfer">
  <bpmn:incoming>SequenceFlow_13</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_14</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Assigns Transfer Team -->
<bpmn:task id="Task_MCMCStaffAssignsTeam" name="MCMC Staff Assigns Transfer Team">
  <bpmn:incoming>SequenceFlow_14</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_15</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Briefs Transfer Team -->
<bpmn:task id="Task_BriefTransferTeam" name="MCMC Staff Briefs Transfer Team">
  <bpmn:incoming>SequenceFlow_15</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_16</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Gives Recommendations for Stabilization -->
<bpmn:task id="Task_GiveRecommendations" name="MCMC Staff Gives Recommendations for Stabilizing Infant">
  <bpmn:incoming>SequenceFlow_16</bpmn:incoming>
```

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  <bpmn:outgoing>SequenceFlow_17</bpmn:outgoing>
</bpmn:task>

<!-- Task: MCMC Staff Gives Operational Recommendations -->
<bpmn:task id="Task_OperationalRecommendations" name="MCMC Staff Gives Recommendations for Transport Team">
  <bpmn:incoming>SequenceFlow_17</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_18</bpmn:outgoing>
</bpmn:task>

<!-- Task: Transfer Team Arrives at Referring hospital -->
<bpmn:task id="Task_ArriveAtHospital" name="Transfer Team Arrives at Referring Hospital">
  <bpmn:incoming>SequenceFlow_18</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_19</bpmn:outgoing>
</bpmn:task>

<!-- Task: Monitor Infant's Condition -->
<bpmn:task id="Task_MonitorCondition" name="Monitor Infant's Condition (Vitals)">
  <bpmn:incoming>SequenceFlow_19</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_20</bpmn:outgoing>
</bpmn:task>

<!-- Task: Test for Infections -->
<bpmn:task id="Task_TestForInfections" name="Test for Infections">
  <bpmn:incoming>SequenceFlow_20</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_21</bpmn:outgoing>
</bpmn:task>

<!-- Task: Record Condition During Transfer -->
<bpmn:task id="Task_RecordCondition" name="Record Infant's Condition During Transfer">
  <bpmn:incoming>SequenceFlow_21</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_22</bpmn:outgoing>
</bpmn:task>

<!-- Task: Neonate Leaves Referring Hospital -->
<bpmn:task id="Task_LeaveHospital" name="Neonate Leaves Referring Hospital">
```

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    <bpmn:incoming>SequenceFlow_22</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_23</bpmn:outgoing>
  </bpmn:task>

  <!-- Gateway: Adverse Conditions During Transport -->
  <bpmn:exclusiveGateway id="Gateway_AdverseConditions" name="Adverse Conditions During Transport">
    <bpmn:incoming>SequenceFlow_23</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_24</bpmn:outgoing>
    <bpmn:outgoing>SequenceFlow_25</bpmn:outgoing>
  </bpmn:exclusiveGateway>

  <!-- Task: Inform Destination Hospital of Adverse Conditions -->
  <bpmn:task id="Task_InformDestinationAdverse" name="Inform Destination Hospital of Adverse Conditions">
    <bpmn:incoming>SequenceFlow_24</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_26</bpmn:outgoing>
  </bpmn:task>

  <!-- Task: Inform Expected Arrival Time -->
  <bpmn:task id="Task_InformArrivalTime" name="Inform Expected Arrival Time to Destination Hospital">
    <bpmn:incoming>SequenceFlow_25</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_27</bpmn:outgoing>
  </bpmn:task>

  <!-- Task: Transfer Neonate to Relevant Ward -->
  <bpmn:task id="Task_TransferToWard" name="Transfer Neonate to Relevant Ward">
    <bpmn:incoming>SequenceFlow_27</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_28</bpmn:outgoing>
  </bpmn:task>

  <!-- Task: Deliver Neonate to Destination Hospital -->
  <bpmn:task id="Task_DeliverNeonate" name="Transport Team Delivers Neonate to Destination">
    <bpmn:incoming>SequenceFlow_28</bpmn:incoming>
    <bpmn:outgoing>SequenceFlow_29</bpmn:outgoing>
```

```
</bpmn:task>

<!-- Task: Share Fate of Infant -->
<bpmn: task id="Task_ShareFate" name="Share Fate of Infant Between Physicians and Nurses">
  <bpmn:incoming>SequenceFlow_29</bpmn:incoming>
  <bpmn:outgoing>SequenceFlow_30</bpmn:outgoing>
</bpmn:task>

<!-- End Event -->
<bpmn:endEvent id="EndEvent_FateShared" name="End Process">
  <bpmn:incoming>SequenceFlow_30</bpmn:incoming>
</bpmn:endEvent>

<!-- Sequence Flows -->
<bpmn:sequenceFlow id="SequenceFlow_1" sourceRef="StartEvent_AssessCondition" targetRef="Task_DoctorAssessesCondition"/>
<bpmn:sequenceFlow id="SequenceFlow_2" sourceRef="Task_DoctorAssessesCondition" targetRef="Task_DoctorExplainsCondition"/>
<bpmn:sequenceFlow id="SequenceFlow_3" sourceRef="Task_DoctorExplainsCondition" targetRef="Gateway_ParentApproval"/>
<bpmn:sequenceFlow id="SequenceFlow_4" sourceRef="Gateway_ParentApproval" targetRef="Task_CoordinateTransfer"/>
<bpmn:sequenceFlow id="SequenceFlow_5" sourceRef="Gateway_ParentApproval" targetRef="Task_EndProcessNoApproval"/>
<bpmn:sequenceFlow id="SequenceFlow_6" sourceRef="Task_EndProcessNoApproval" targetRef="EndEvent_FateShared"/>
<bpmn:sequenceFlow id="SequenceFlow_7" sourceRef="Task_CoordinateTransfer" targetRef="Task_DoctorSendsForm"/>
<bpmn:sequenceFlow id="SequenceFlow_8" sourceRef="Task_DoctorSendsForm" targetRef="Task_DoctorSelectsHospitalLevel"/>
<bpmn:sequenceFlow id="SequenceFlow_9" sourceRef="Task_DoctorSelectsHospitalLevel" targetRef="Task_InformMCMCLevel"/>
<bpmn:sequenceFlow id="SequenceFlow_10" sourceRef="Task_InformMCMCLevel" targetRef="Task_MCMCGradesTransfer"/>
<bpmn:sequenceFlow id="SequenceFlow_11" sourceRef="Task_MCMCGradesTransfer" targetRef="Task_MCMCDeterminesDestination"/>
<bpmn:sequenceFlow id="SequenceFlow_12" sourceRef="Task_MCMCDeterminesDestination" targetRef="Task_MCMCInformsDoctor"/>
```

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  <bpmn:sequenceFlow id="SequenceFlow_13" sourceRef="Task_MCMCInformsDoctor" targetRef="Task_MCMCStaffTriagesTransfer"/>
  <bpmn:sequenceFlow id="SequenceFlow_14" sourceRef="Task_MCMCStaffTriagesTransfer" targetRef="Task_MCMCStaffAssignsTeam"/>
  <bpmn:sequenceFlow id="SequenceFlow_15" sourceRef="Task_MCMCStaffAssignsTeam" targetRef="Task_BriefTransferTeam"/>
  <bpmn:sequenceFlow id="SequenceFlow_16" sourceRef="Task_BriefTransferTeam" targetRef="Task_GiveRecommendations"/>
  <bpmn:sequenceFlow id="SequenceFlow_17" sourceRef="Task_GiveRecommendations" targetRef="Task_OperationalRecommendations"/>
  <bpmn:sequenceFlow id="SequenceFlow_18" sourceRef="Task_OperationalRecommendations" targetRef="Task_ArriveAtHospital"/>
  <bpmn:sequenceFlow id="SequenceFlow_19" sourceRef="Task_ArriveAtHospital" targetRef="Task_MonitorCondition"/>
  <bpmn:sequenceFlow id="SequenceFlow_20" sourceRef="Task_MonitorCondition" targetRef="Task_TestForInfections"/>
  <bpmn:sequenceFlow id="SequenceFlow_21" sourceRef="Task_TestForInfections" targetRef="Task_RecordCondition"/>
  <bpmn:sequenceFlow id="SequenceFlow_22" sourceRef="Task_RecordCondition" targetRef="Task_LeaveHospital"/>
  <bpmn:sequenceFlow id="SequenceFlow_23" sourceRef="Task_LeaveHospital" targetRef="Gateway_AdverseConditions"/>
  <bpmn:sequenceFlow id="SequenceFlow_24" sourceRef="Gateway_AdverseConditions" targetRef="Task_InformDestinationAdverse"/>
  <bpmn:sequenceFlow id="SequenceFlow_25" sourceRef="Gateway_AdverseConditions" targetRef="Task_InformArrivalTime"/>
  <bpmn:sequenceFlow id="SequenceFlow_26" sourceRef="Task_InformDestinationAdverse" targetRef="Task_TransferToWard"/>
  <bpmn:sequenceFlow id="SequenceFlow_27" sourceRef="Task_InformArrivalTime" targetRef="Task_TransferToWard"/>
  <bpmn:sequenceFlow id="SequenceFlow_28" sourceRef="Task_TransferToWard" targetRef="Task_DeliverNeonate"/>
  <bpmn:sequenceFlow id="SequenceFlow_29" sourceRef="Task_DeliverNeonate" targetRef="Task_ShareFate"/>
  <bpmn:sequenceFlow id="SequenceFlow_30" sourceRef="Task_ShareFate" targetRef="EndEvent_FateShared"/>
 </bpmn: process>
</bpmn: definitions>
```