Retinopathy of Prematurity Computerized Screening and Monitoring System in a Tertiary Hospital in the Philippines

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ABSTRACT

Background and Objective. Retinopathy of Prematurity (ROP) is a significant cause of blindness in childhood. It is the leading cause of vision loss worldwide and 8.4% of childhood blindness in the Philippines. It is potentially avoidable if detected early and treated promptly. The study's objective was to prevent the dreaded complication of lifelong blindness from ROP in premature babies admitted at our institution by ensuring timely referrals, timely screenings, and prompt treatment.

Methods. An observational, single-center study was conducted from August 2022 to July 2023. ROP monitoring and screening system with an automated computer alarm was developed. A total of 241 admitted babies with ROP risk factors were enrolled in the database. We were guided by the computer alarm system on the proper timing of referrals and screenings for ROP and detecting patients with missed screenings.

Results. The study included 241 babies. All patients (100%) were screened for ROP. There were 15 (6%) patients diagnosed with ROP upon initial screening. For timeliness, 234 (97%) have timely referrals, and 232 (96%) have timely screenings. The most common reason for delayed referrals and screenings was waiting to wean patients off the ventilation support before referring them for ROP screening. No patient enrolled in the database missed ROP screening. However, in comparison with the total number of admissions with risk factors for ROP versus the total number of patients in the database, two (2%) were not enrolled in the database due to the resident's confusion in the ROP referral parameter (born term with low birth weight). Problems during the implementation were identified and addressed.

Conclusion. The database and alarm system for monitoring and screening ROP was a helpful tool to healthcare workers for a timely interdepartmental referral and screening system for premature patients at risk for ROP. ROP screenings were recommended even if patients were hooked to assisted ventilation

Keywords: retinopathy of prematurity, ROP, ROP screening, database

INTRODUCTION

The leading cause of vision loss among children worldwide is Retinopathy of Prematurity (ROP).[1] In the Philippines, 8.4% of childhood blindness results from ROP.[2] In a study in 2013 by a local tertiary hospital, ROP had a 24% incidence.[3] In our institution, 39 out of 586 (6%) patients screened from 2019-2021 were diagnosed with ROP.

ROP is a significant cause of childhood blindness, but it is potentially avoidable if detected early and treated promptly.[4] The challenges in the management of ROP are delays in referrals, delays in screenings, and missed screenings, which all lead to late detection of ROP, leading to its dreaded complication, which is permanent blindness. Given that lifetime blindness is a grave consequence of ROP, even one baby with severe ROP is considered a problem in the institution's referral system.

This study created a computer database for ROP screening and monitoring, equipped with an automated alarm system to help ensure that stakeholders were reminded to conduct ROP screenings on schedule and prevent delays. The 2020 Retinopathy of Prematurity Philippine Preventive Care Plan Strategy guidelines were utilized for the alarm parameters.[5] The significance of this study was to ensure timely referrals and screenings, which contribute to early detection and management of ROP. Therefore, no single baby admitted at our institution would go blind from ROP.

MATERIALS AND METHODS

This was a prospective, observational, single-center study, conducted from August 2022 to July 2023. The study pioneered and set up a database with a multi-department computerized screening and monitoring alarm system for ROP. The ROP monitoring system was accessible from the hospital's main electronic medical record (EMR).

The sample size was determined by all admitted premature babies with risk factors for developing ROP based on the 2020 Retinopathy of Prematurity Philippine Preventive Care Plan Strategy guidelines.[5]

Inclusion Criteria

The inclusion criteria were all admitted newborns with < 32 weeks AOG or with a birth weight of ≤1500 grams, or with AOG of ≥32 weeks to <36 weeks who have at least one of the risk factors for developing ROP. Risk factors for ROP include severe sepsis, transfusion of PRBC within the first ten days, oxygen use, and prematurity with an unstable clinical course.

There was a 2-point entry:
1. All qualified patients were born and admitted to our institution.
2. All qualified patients from other institutions who were referred and admitted to our institution.

Multiple steps were taken to address potential biases. Selection bias was addressed by including in the study all qualified premature newborns admitted in our hospital from August 2022 to July 2023, whether institutional or non-institutional deliveries. Recall bias was addressed by counterchecking the information and census gathered in the computer database with the census from the manual ROP logbook and the census of all admitted newborns from the medical records.

Exclusion Criteria

Any admitted premature babies who went home against medical advice, and babies born in other institutions who were referred for ROP screening at the outpatient clinic, were excluded from the study.

ROP Monitoring and Alarm System Development

The primary investigator worked together with the Retina Section of the Department of Ophthalmology, the Department of Pediatrics and their Neonatology section, the Ophthalmology and Pediatric nurses, and the Integrated Hospital Operations and Management (IHOMP) of the institution to create the referral and screening system.

The IHOMP developed the database and integrated the computerized screening and monitoring alarm system into the hospital's EMR. They ensured the accuracy and ease of use of the alarm system. The institution has an internet provision of 200 megabits per second (mbps) each for two different internet providers to ensure EMR data coverage and backup. There were also adequate dedicated computers in every department for the EMR.

After the computerized screening and monitoring alarm system was completely set up and implemented, a pilot run was conducted on 11 sample patients before actual data gathering. This was crucial for quality checks, the system's ease of use, and the correction of technical glitches. The pilot run gave enough time to modify the referral algorithm and program for better accuracy.

Process Flow

The procedure started at the Admitting section, where the personnel admitted all premature babies in our institution. Then, the Pediatric resident enrolled all the patients who met the inclusion criteria for ROP screening in the database. In the database, there was a list of qualified premature babies awaiting referral and screening for ROP, and their recommended dates for initial screening. The Pediatric resident officially referred patients to the Ophthalmology resident using the hospital's interdepartmental referral form. The Ophthalmology resident received the interdepartmental referral forms and logged the patients in a separate logbook. The alarm was visible to and can be monitored by all involved departments (Ophthalmology, Pediatrics, and Nursing Department).

The alarm was turned ON once each patient reached the recommended date of referral and screening. The alarm system parameters were:

1. All born at <28 weeks AOG, the alarm was set for initial screening at 31 weeks or before discharge, whichever was earlier.
2. For all babies ≥28 weeks AOG, the alarm was set for initial screening at 20 days post-natal age or before discharge, whichever was earlier.

The alarm was also turned ON when the system detected any patient discharged from the hospital without initial ROP screening.

Before conducting the ROP screening, the Ophthalmology resident obtained a signed written consent form from the patient's parent and explained the procedure. A copy of the signed consent form was given to the parent or guardian. The Ophthalmology resident and a Retina specialist performed the initial ROP screenings and input the findings into the computer database. Updating the database with the screening findings prompted the alarm to turn OFF. Furthermore, the Ophthalmology resident and consultant monitored subsequent screenings and provided follow-up instructions and schedules, following the existing standard of care for ROP (Figure 1).

This is a one-year report of the data gathered. For the data analysis, the count was one per baby, regardless of the ROP status in one or both eyes. If a baby had ROP in both eyes, the count was only one, with the diagnosis of the more severe form of ROP noted in the case report form. Through the system, we were able to get the following outcomes:

Primary Outcomes
1. Actual number and percentage of babies at risk for ROP who were screened.
2. Actual number and percentage of babies at risk for ROP who were referred on time. (within 24 hours from the alarm, or earlier)
3. Actual number and percentage of babies at risk for ROP who underwent screenings on time (on or before the alarm date)
4. Percentage of missed ROP screenings.

Secondary Outcomes
1. Percentage of compliance/utilization among departments (number of days the system was not followed or used / 365 days)
2. Number and percentage of newborns enrolled in the system, but died before screening
3. List of problems identified during the implementation

RESULTS

The total number of patients who were referred and screened for ROP from August 2022 to July 2023 are presented in Tables 1 and 2.

The study ran for 365 days, from August 2022 to July 2023. The total number of patients enrolled in the study was
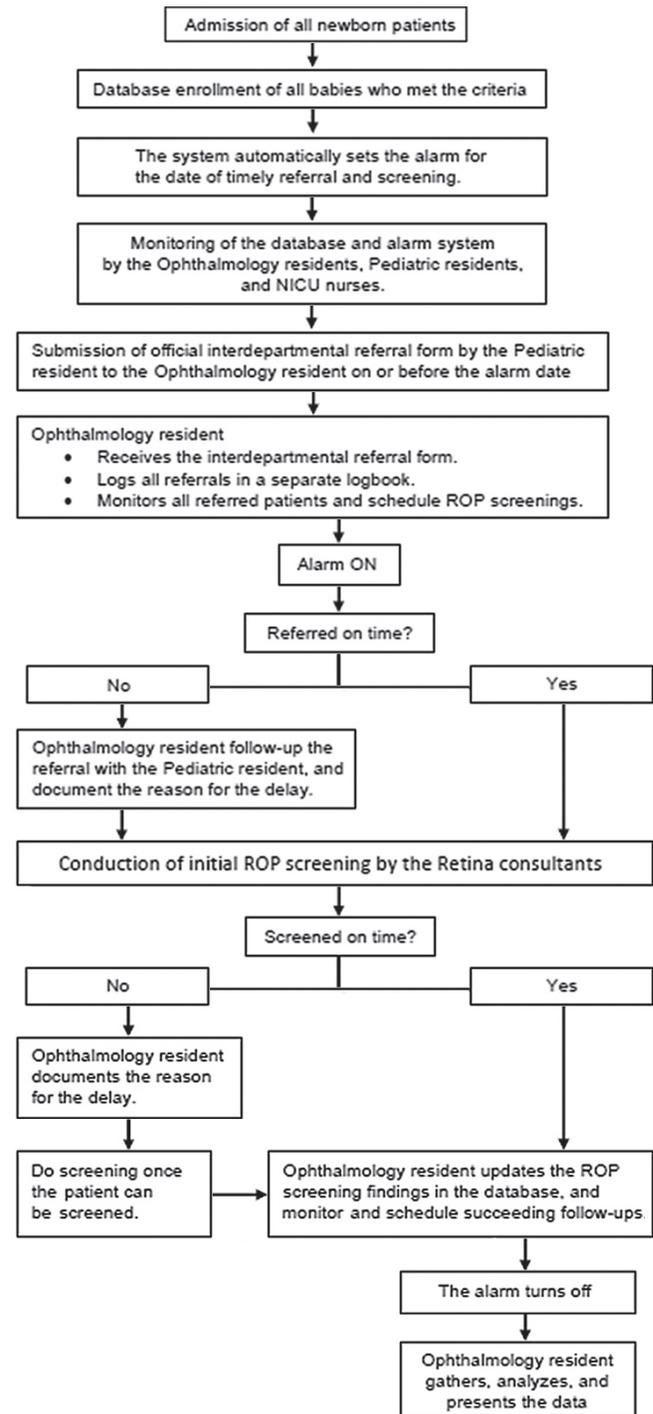

Figure 1. Flowchart of the procedure.

Table 1. Monthly Tally of Referred and Screened Patients from August 2022 to July 2023

Month	Total number of patients referred	Total number of patients that were referred but died before screening	Total number of patients for initial screening	Percentage of patients screened	Percentage of patients not screened
August 2022	24	0	24/24	100%	0
September 2022	20	1	19/19	100%	0
October 2022	20	1	19/19	100%	0
November 2022	25	0	25/25	100%	0
December 2022	24	1	23/23	100%	0
January 2023	30	0	30/30	100%	0
February 2023	15	0	15/15	100%	0
March 2023	10	0	10/10	100%	0
April 2023	14	0	14/14	100%	0
May 2023	27	0	27/27	100%	0
June 2023	21	0	21/21	100%	0
July 2023	14	0	14/14	100%	0
Total	244	3	241/241	100%	0

Table 2. Primary Outcomes for ROP Monitoring and Alarm System

	Total Number	Percentage
Number of patients referred for ROP screening	244	NA
Number of patients referred but died before screening	3	1%
Number of patients screened (total number of patients referred for ROP screening – number of patients referred but died before screening)	241	NA
Number of patients referred on time	234	97%
Number of patients screened on time	232	96%
Number of missed ROP screening	0	0
Number of patients diagnosed with ROP upon initial screening (Incidence of ROP for 2022-2023 in the institution)	15	6%

244. Of these, 242 patients were born in our institution, while two were non-institutional deliveries who were referred and admitted to our hospital. Among the 244 referred patients, three (1%) died before the screening date. Of the remaining 241 patients, all (100%) had initial ROP screenings done, and 15 (6%) were diagnosed with ROP on initial screening. As for the timing, nine (4%) patients did not have timely referrals and screenings. Of these, two (22%) were referred on time but screened late, while seven (4%) did not have timely referrals that subsequently delayed the screenings. The profiles of patients with delayed referrals and screenings are shown in Table 3.

As seen in Table 4, the reasons for delays were: eight (89%) had an unstable clinical course and episodes of desaturation that needed ventilation assistance and were referred or screened after being weaned from assisted ventilation, while one (11%) was born from another institution and was referred to and admitted at our institution, due to failure to thrive, beyond the recommended time for initial screening. Nevertheless, 234 (97%) patients were referred on or before the alarm date, and 232 (96%) had timely screenings. No eligible patients enrolled in the database have missed the screening.

The database and alarm systems were utilized for 365 days and achieved a 100 percent compliance rate. Patients who had delayed referrals, delayed screenings, and had their alarm systems activated were closely monitored by the Ophthalmology resident. Communication with the Pediatric residents and nurses was maintained throughout the process. Once the Ophthalmology resident updated the screening findings in the EMR, the alarm systems were automatically turned off.

DISCUSSION

Our study showed that the database, and monitoring and screening systems, if fully utilized, guide the Ophthalmologists, Pediatricians, and nurses to the proper timing of referral and screening for ROP of premature babies with ROP risk factors admitted in our hospital. It has increased awareness, communication, and coordination among the involved healthcare workers and helped prevent delays in referrals, screenings, and missed screenings.

Of the 241 eligible patients enrolled in the database, 100% were screened for ROP. For timeliness, 234 (97%) premature

Table 3. Profiles of Patients with Delayed Referrals and Screenings

	AOG (weeks)	BW (kg)	S	T	O	P	Alarm date	Referral date	Screening date	Referred on time	Screened on time	Findings
1	30	1.4	Yes	No	Yes	Yes	07/28/22	08/05/22	08/11/22	NO	NO	ROP
2	30	1.2	No	Yes	Yes	Yes	12/28/23	01/02/23	01/09/23	NO	NO	Immature retina
3	31	1.3	No	No	Yes	Yes	12/18/22	12/25/22	12/29/22	NO	NO	Mature retina
4	36	1.8	Yes	Yes	Yes	Yes	07/14/22	09/13/22	09/15/22	NO	NO	Immature retina
5	32	1.4	No	Yes	Yes	Yes	09/27/22	10/27/22	10/27/22	NO	NO	Immature retina
6	32	1.9	No	No	Yes	Yes	01/16/23	01/28/23	01/30/23	NO	NO	ROP
7	29	1.0	Yes	No	Yes	Yes	09/10/22	09/07/22	10/11/22	YES	NO	ROP
8	30	1.3	No	No	Yes	Yes	04/19/23	04/12/23	04/23/23	YES	NO	ROP
9	34	2.1	No	No	Yes	Yes	5/25/23	06/03/2023	06/05/2023	NO	NO	ROP

AOG – Age of gestation, BW – Birth weight, S – Sepsis, T – Transfusion of blood, O – Oxygen use, P – Prematurity with unstable clinical course

Table 4. List of Reasons for the Delay in ROP Referrals and Screenings

Patient number	Referred on time	Screened on time	Reasons for the delay in referral and screening
1	NO	NO	• Cardio-pulmonary arrest upon birth, revived and hooked to MV • Referred for ROP screening after being weaned off from MV
2	NO	NO	• Desaturation upon birth and hooked to NCPAP • Referred for ROP screening after being weaned off from NCPAP
3	NO	NO	• Hooked to MV upon birth and eventually shifted to NCPAP. • Referred for ROP screening after being weaned off from NCPAP
4	NO	NO	• Born in another institution • Referred to MMMHMC due to failure to thrive • Admitted in MMMHMC past the alarm date
5	NO	NO	• Respiratory distress upon birth and hooked to MV • Referred for ROP screening after being weaned off from MV
6	NO	NO	• Respiratory distress upon birth and hooked to MV • Referred for ROP screening after being weaned off from MV
7	YES	NO	• Cyanotic upon birth and hooked to MV • Referred on time but intermittent episodes of desaturations caused a delay in screening
8	YES	NO	• Cyanotic upon birth and hooked to MV • Referred on time but intermittent episodes of desaturations caused a delay in screening
9	NO	NO	• Respiratory distress upon birth and hooked to MV • Referred for ROP screening after being weaned off from MV

MV – Mechanical Ventilator, NCPAP - Nasal Continuous Positive Airway Pressure

babies at risk for ROP admitted at our hospital have timely referrals, and 232 (96%) have timely ROP screenings. The study showed that the most common reason for the delay in referral was the patient's unstable clinical course with assisted ventilation and waiting to wean off patients from the ventilation support before being referred for ROP screening. Consequently, this has caused the most common reason for the delay in ROP screening. There were 15 (6%) patients diagnosed with ROP on initial screening.

To be able to verify if all the premature babies at risk for ROP were all enrolled in the database for ROP screening, we compared the total number of neonates with risk factors for ROP admitted in our hospital per month with the total number of patients enrolled in the database using the objective data: those who were born at 32 weeks AOG or less and with a birth weight of 1500 grams or less. The data is presented in Table 5. The referrals of patients born at 33-36 weeks AOG were determined by the pediatrician based on their assessment of the patient's risk factors for ROP during the course in the ward.

After cross-checking the census of patients in the database with the census of all admitted neonates with risk factors for ROP, we determined that two (2%) patients were not enrolled in the database and went home without referrals for ROP screening. Both patients were born term at 37 weeks AOG with a stable course in the ward and did not have oxygen supplementation, blood transfusion, or sepsis. However, both have a birth weight of 1400 grams, which was

Table 5. Patients Admitted in MMMH&MC who were Born ≤32 weeks AOG and/or with a BW of ≤1500 grams per Month

Month	Total number of patients born ≤32 weeks AOG and/or ≤1500 grams	Total number of patients born ≤32 weeks AOG and/or ≤1500 grams who died before enrollment	Number of patients born ≤32 weeks AOG and/or ≤1500 grams who were enrolled in the database	Number of patients born ≤32 weeks AOG and/or ≤1500 grams who were not enrolled in the database	Percentage of patients born ≤32 weeks AOG and/or ≤1500 grams who were enrolled in the database
August 2022	16	8	8/8	0	100%
September 2022	10	3	7/7	0	100%
October 2022	19	10	9/9	0	100%
November 2022	19	5	13/14	1	93%
December 2022	8	1	7/7	0	100%
January 2023	10	6	4/4	0	100%
February 2023	7	3	4/4	0	100%
March 2023	13	8	5/5	0	100%
April 2023	12	6	6/6	0	100%
May 2023	26	10	15/16	1	94%
June 2023	16	7	9/9	0	100%
July 2023	22	10	12/12	0	100%
Total	178	77	99	2	99%

AOG – Age of gestation, BW – Birth weight

still a risk factor in developing ROP. The Ophthalmology resident notified the Pediatric resident-in-charge of the patient. The reason for the missed enrollment and referral of both patients was the confusion of the resident-in-charge regarding the criteria for referral to ROP screening. The Ophthalmology resident called the parents of each patient, explained what ROP is, and gave an immediate appointment for a dilated fundoscopy examination at the outpatient clinic.

The computerized ROP monitoring and screening system was used daily from August 2022 to July 2023, with 100% compliance from the involved departments. No problem was encountered, such as system errors or breakdowns. Problems identified during the implementation of the computerized screening and monitoring system were the following:

Confusion with the changing of the patient's name in the database from the initial registered name in the EMR to the Philippine Statistical Authority (PSA) registered name. The problem was solved by counter-checking using the patient's assigned hospital number.

1. Delayed referral and ROP screening of patients with assisted ventilation. This was addressed by giving recommendations for improvement of the referral and screening system based on the gathered research data.
2. Missed referral of two patients born at term, but with low birth weight. This was addressed by immediate communication. The Ophthalmology resident immediately notified the Pediatric resident, reiterated the criteria for having risk factors for ROP, and called the parents of the patients to give ROP screening appointments and instructions.

To ensure the continuation of the ROP database, monitoring, and screening alarm system. We recommend the following:
A. The ROP database, monitoring, and alarm systems should be integrated into the hospital system and protocols.
B. Continued endorsement to the new Pediatric and Ophthalmology residents regarding the database and alarm systems.
C. Yearly education and re-orientation of the Pediatric and Ophthalmology staff nurses on ROP and the ROP monitoring and alarm system.

In this study, the most common reason for the delay in ROP referral and screening was the long wait for patients to be weaned off from assisted ventilation before referring or screening for ROP. To prevent delay in referral and screening for ROP, we, therefore, recommend the following:
D. Perform ROP screenings even if patients are hooked to assisted ventilation. The Retina specialist and Ophthalmology resident will perform ROP screenings on patients hooked to a mechanical ventilator or NCPAP, together with a pediatrician who will monitor them during the procedure.
E. The Pediatric residents are to enroll all patients with ROP risk factors in the database upon the patient's hospital admission. The Ophthalmology resident will monitor the patients in the database for the timing of screening.

F. For any patient deemed unsuitable to undergo ROP screening by the Pediatric resident due to their unstable course on the day of screening, the Ophthalmology resident shall follow up daily and do the screening immediately once the patient is stable.

To prevent missed referrals for ROP screening of premature babies with ROP risk factors, we strongly recommend:

G. The pediatric residents are to enroll in the database all patients who were born ≤32 weeks AOG, regardless of birth weight, and all patients with a birth weight of ≤1500 grams, regardless of AOG upon hospital admission. Once in the database, the Ophthalmology resident will monitor the patients for the timing of screening.

Due to the length of development and documentation involved in the ROP computerized monitoring and screening system, we recommend:

H. A separate research protocol by an Ophthalmology resident that will further develop the system, gather, and analyze all the data and outcomes from the database. In this subsequent report, data analysis can be presented related to the number of patients with all-stage ROP, breakdown of specific stages of ROP, number of screened patients with treatment-warranted ROP, number of screened patients with end-stage ROP, demographics of the babies with ROP, the treatment, and treatment outcomes.

CONCLUSION

In conclusion, the results of this study showed that the created database and alarm system for monitoring and screening ROP was a helpful tool to guide healthcare workers to a timely interdepartmental referral and screening system for premature patients at risk for ROP. There were high rates for timely referral and screening following the utilization of the system. ROP screenings were recommended even if patients were hooked to assisted ventilation. A regular re-orientation in the system is necessary to continue achieving the goal of zero missed screenings and no blind babies due to ROP.

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