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Visual impairment due to retinopathy of prematurity and concomitant disabilities in the Netherlands

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ABSTRACT

Aim: Determine incidence of visual impairment due to retinopathy of prematurity (ROP) and concomitant disabilities between 2009 and 2018 in the Netherlands and compare data to four former similar studies. Secondly, monitor if infants were missed for ROP-screening since the adoption of stricter, risk factor guided criteria (2013).
Methods: Retrospective inventory on anonymous data of infants diagnosed with ROP from Dutch visual impairment-institutes. Data including: best corrected visual acuity, ROP-treatment and concomitant disabilities: bronchopulmonary dysplasia, behavioral abnormalities, epilepsy, hearing deficit, developmental delay, cerebral palsy and cerebral visual impairment. During the study period, lower age limit for neonatal life support (2010) and higher oxygen saturation targets (2014) were implemented.
Results: Records of 53 infants were analyzed. Visual impairment incidence due to ROP was 2.02 per 100.000 live births (2000–2009: 1.84, $p = 0.643$). Compared to earlier periods (1975–2000), a significant decrease was observed. The incidence of concomitant disabilities remained stable. Mean gestational age (GA) continued to decrease to 26.6 ± 1.9 weeks (2000–2009: 27.4 ± 2.0 weeks, $p = 0.047$). All patients met the screening inclusion criteria.
Conclusion: The incidence of visual impairment due to ROP and concomitant disabilities between 2009 and 2018 has not increased, despite lower GA and higher oxygen saturation targets. None of the infants were missed for ROP screening following introduction of more restricted screening inclusion criteria.

1. Introduction

Retinopathy of prematurity (ROP) continues to be a leading cause of preventable blindness in premature infants [1]. ROP rates vary among countries, as they are strongly dependent on both neonatal and ophthalmological care. Currently, the highest incidence is seen in rapidly developing economies, mainly due to improvements in neonatal care in combination with limited awareness of pathophysiology and consequences of ROP and ophthalmological resources [2]. But also in high income countries, including the Netherlands, the number of infants developing severe ROP (sROP) is increasing as more infants at risk survive [3–7].

From 1975 onwards, four Dutch periods were carried out to evaluate the incidence of visual impairment due to ROP and incidence of

Abbreviations: BW, birth weight; BCVA, best corrected visual acuity; BPD, bronchopulmonary dysplasia; ETROP, early treatment for ROP; GA, gestational age; GDRP, General Data Protection Regulation; NEDROP, the Netherlands retinopathy of prematurity study; NeOProM, the Neonatal Oxygenation Prospective Meta-analysis Collaboration study; NICU, neonatal intensive care unit; ROP, retinopathy of prematurity; sROP, severe ROP; VA, visual acuity; VEGF, vascular endothelial growth factor.

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accompanying disorders [8–10]. Each study demonstrated a decrease in gestational age (GA) and birth weight (BW) of the affected patients compared to the previous period. Regarding the incidence of visual impairment, the first two inventories (1: 1975–1987 and 2: 1985–1994) showed an increase, however from 1994 onwards (3: 1994–2000 and 4: 2000–2009), a gradual but significant decrease was observed. This decrease in visual impairment was however not accompanied by an equal decline in accompanying disabilities. Period 4 revealed, that two-thirds of the children with visual impairment due to ROP were multiply disabled – defined as visual impairment with presence of one or more concomitant disabilities – illustrating the high vulnerability of this population.

During the present study period (2009–2018) several changes were implemented in neonatal care in the Netherlands that likely increased the risk for sROP. Firstly, GA for active neonatal treatment was lowered from 25.0 to 24.0 weeks (2010), which resulted in more extremely premature infants surviving the neonatal period [4]. Second, following an interim meta-analysis of the NeOProM group of studies (2014) [11], higher oxygen saturation targets were accepted in most Dutch neonatal intensive care units (NICUs) because they warrant better survival. In 2013 a new screening and treatment guideline was implemented following a national inventory on ROP in the Netherlands (NEDROP, 2009) [12,13], with narrowed risk factor guided screening inclusion criteria that focus on infants with the highest risk of ROP [14,15].Safety monitoring of the guideline has not taken place until now. Finally, the Early Treatment for ROP (ETROP) criteria were emphasized in the guideline, possibly leading to treatment decisions at earlier stages (more infants requiring treatment) and therefore, improved treatment outcome [16].

All these policy changes are expected to influence the incidence and outcome of (severe) ROP. Thus, it is pivotal to periodically monitor potential sequelae and if necessary, adjust current policies. Together with previous periods, the present and fifth inventory on visual impairment due to ROP and concomitant disabilities provides insight into over four decades of ROP sequelae in the Netherlands. Secondly, the purpose is to verify the safety of the 2013 ROP guideline, by determining if infants who were registered in the Dutch institutes for the visually impaired and blind, were missed for screening as they did not fit the new, more restricted inclusion criteria (Table 1).

2. Materials & methods

This study was initiated by the Leiden University Medical Center. Data from the present, 9-year study period were compared to the previous (2000–2009) and earlier periods going back to 1975. For comparison, an identical approach toward data analysis was chosen.

Ophthalmologists of the Dutch institutes for the visually impaired and blind provided anonymized data of patients born between January 1st 2009 and December 31st 2017 (2009–2018), who were referred to their center with the diagnosis of visual impairment due to (severe) ROP as the main reason for referral (regardless of visual acuity at time of admission). A one year overlap with the previous period (period 4) for the year 2009 was calculated as data collection in all periods was conducted in the final year of the study period. Therefore, it could not be guaranteed that all infants who became visually impaired due to ROP were already registered at the VI institutes at time of the former inventory. According to the General Data Protection Regulation (GDPR) [17] and the local medical ethical committee, informed consent was not required, as no personalized data (for example birth year) were provided.

Visual impairment was defined as visual acuity (best corrected visual acuity, BCVA) of <0.3 in the best eye, according to the recommendations of the International Association for Prevention of Blindness (WHO, 1984) [18]. The referrals also included infants who did not meet the WHO criteria for visual impairment and blindness, as the institutes also provide a rehabilitation program to children with ROP who have an increased risk of developing visual complications due to neonatal risk factors and because of borderline visual acuity (VA), cerebral visual impairment or unilateral blindness.

Ophthalmological data were collected on VA and treatment for ROP. In many cases data on age of VA examination and VA test method were not provided. If an infant was incapable for reliable VA assessment, VA was designated unknown. In other cases, VA was categorized as follows: not partially sighted or blind: VA > 0.3, partially sighted: VA 0.1–0.3, socially blind: VA 0.1–1/60, practically blind: VA <1/60-light perception (LP), completely blind VA: no LP. Information on anatomic and = refractive status could not be obtained or was unknown in many cases and therefore excluded from the study. In the Netherlands, the Early Treatment for ROP (ETROP) criteria apply for ROP treatment. According to the Dutch guideline, anti-VEGF was used only for ROP stage 3 with plus disease in zone I and as last resort treatment. Neonatal data consisted of: GA, BW, sex, multiple birth and neonatal treatment. Due to the GDPR however, obtaining details on treatment was challenging compared to period 1–4. For example, in up to 70 % of all cases, information about the duration of supplemental oxygen or mechanical ventilation were missing and therefore excluded from this study. Regarding concomitant disabilities, presence of bronchopulmonary dysplasia (BPD, defined as the need for supplemental oxygen at 28 days of life), behavioral abnormalities (classification according to the Diagnostic and Statistical Manual of mental disorders), epilepsy, hearing deficit (defined as bilateral hearing loss≥40 dB), developmental delay (defined as at least 6 months disparity with a comparable age group with no improvement in relation to earlier assessment, according to the Dutch adaptation of the Reynell-Zinkin developmental scales for visually handicapped children [19]), and neurological handicap (defined as treated hydrocephalus, posthemorrhagic ventricular dilatation, cerebral palsy and cerebral visual impairment) were recorded. Infants were considered multiply disabled when they had visual impairment caused by ROP and one or more concomitant disabilities, except for BPD as quality of life improves in adolescence and young adulthood, because pulmonary function usually improves over time [20]. To calculate incidences Dutch birth rates were used as denominator. Birth rate data were collected from the Central Bureau of Statistics for the Netherlands [21] and survival rates were obtained from the Dutch national perinatal registry, Perined [22].

Statistical analysis was performed using SPSS Statistics software version 23.0 IBM Corp., Armonk, N.Y., USA. Clinical data were evaluated using the chi-square test and independent samples *t*-test. The incidence of visual impairment in relation to Dutch birth rates was analyzed using Poisson regression analysis. For the purpose of comparing infants with visual impairment to the previous periods, the total study population was used as denominator. Differences with a *p*-value <0.05 were considered significant.

Table 1
Inclusion criteria for ROP screening according to the previous and present Dutch guideline. In 2013 gestational (GA) and birth weight (BW) were lowered and risk factors* were included: mechanical ventilation, sepsis, necrotizing enterocolitis, postnatal corticosteroids and hypotension treated with cardiotonic agents.

Guideline	Previous (1997)	Present (2013)
GA/BW	<32.0 weeks and/or <1500 g	<30.0 weeks and/or <1250 g
Additional criterion	–	30.0–32.0 weeks and/or 1250–1500 g and presence of ≥1 risk factor*

3. Results

3.1. General data

Records of 53 infants referred to Dutch institutes for the visually impaired with the (presumed) diagnosis of visual impairment due to ROP were obtained. All children were born with GA < 30.0 weeks and/or BW < 1250 g and would have therefore been included for ROP screening according to the new screening criteria. Mean population GA and BW continued to decrease to 26.6 ± 1.9 weeks (period 4: 27.4 ± 2.0, $p = 0.047$) and 823 ± 323 g (vs. period 4 $p = 0.349$, period 1 $p = 0.003$) respectively. The incidence of male gender and multiple births did not change. Other general and neonatal data of the children in the current (period 5, 2009–2017) and previous periods (periods 1–4) are presented in Table 2.

3.2. Visual impairment

Thirty-two of the 53 infants (60.4 %) were registered as visually impaired based on VA < 0.3, representing a nonsignificant decrease since period 4 (2000–2009) (32/42 = 76.2 %, $p = 0.103$). Compared to period 3 however, in which 46/51 (90.2 %) infants had VA < 0.3, the incidence was significantly lower ($p = 0.02$).

The absolute number of live births in the Netherlands with GA < 25.0 weeks was more than three times higher ($n = 573$) than in period 4 (188). Contrarily, the number of infants born GA > 25.0 did not change. In relation to the overall birth rate, the incidence of visual impairment due to ROP was 2.02 per 100.000 (Table 3), representing a non-significant change since period 4 ($p = 0.643$). Yet compared to period 3 and 2, a notable difference was observed ($p = 0.005$ and < 0.001 respectively).

In two patients details about VA were unknown. One preverbal child with ROP stage 5 in both eyes was categorized as completely blind. For the other children, the distribution per category has not changed since period 4 (Table 4). Though the absolute number of completely blind infants (no light perception, LP) was nearly three times as high compared to period 4, the increase was not significant ($p = 0.119$). Moreover, the number of blind children VA < 1/60-LP (practical blindness), showed a parallel threefold decrease. Nineteen infants were not partially sighted or blind, of which 16 had VA >0.3 and three were unilaterally blind. Within this group, ten were treated for ROP, two had stage 2 ROP but were also diagnosed with cerebral visual impairment and in six infants, the details about the course of ROP were unknown. Of all children registered with diagnosis of ROP, eight children (15.1 %) had cerebral visual impairment of which three had VA > 0.3, four were partially sighted (VA0.1–0.3) and one was blind (VA < 1/60-LP).

3.3. Treatment

ROP treatment was performed in 35 children (66.0 %) using retinal laser photocoagulation ($n = 29$, 82.9 %), combined laser and intravitreal anti-vascular endothelial growth factor (VEGF) therapy ($n = 1$), laser and cryotherapy ($n = 1$), anti-VEGF ($n = 1$), pars plana vitrectomy ($n = 1$) and cryotherapy ($n = 2$). Eighteen infants (34.0 %) were not treated for ROP of which 9/53 (17.0 %) had a VA < 0.3 (period 4: 14/42 (33.0 %) untreated of which ten (23.8 %) VA < 0.3). Within this group, three children were included of which data on ROP treatment were unknown. Only compared to period 2 (and earlier), treatment was performed more often ($p = 0.01$).

Table 3
Visual impairment[a] caused by ROP (sequelae) in relation to overall birth rates in the Netherlands.
In the present study 32/53 of the registered infants were visually impaired.

Period	Years	No. ROP sequelae	No. live births × 10^5	ROP sequelae/ 100.000
1	1975–1987	97	23.0	4.22
2	1986–1994	79	14.4	5.49
3	1994–2000	46	11.7	3.93
4	2000–2009	32	17.4	1.84
5	2009–2018	32	15.8	2.02

[a] Defined as visual acuity <0.3 in the best eye.

3.4. Concomitant disabilities

The incidence of concomitant disabilities found in infants with ROP also seems to have reached a plateau (Table 5). Though the absolute number of infants with behavioral abnormalities and a hearing deficit nearly halved, the difference did not reach statistical significance ($p = 0.092$ and 0.157 respectively). The number of children with at least one concomitant disability was 45 (84.9 %) (period 4: 73.8 %, $p = 0.179$) and is high for all infants with GA < 30 weeks (Table 6).

4. Discussion

This is the fifth consecutive inventory on incidence of visual impairment due to ROP in the Netherlands, providing a national overview of more than four decades. Between 2009 and 2018, records of 53 children were obtained, who were referred to Dutch institutes for the visually impaired or blind because of visual impairment due to ROP. All children were eligible for screening according to the new risk-based and more stringent inclusion criteria. Thus, though fewer infants were subjected to screening examinations, no infants with visual impairment due to ROP were missed because they no longer fitted the criteria, confirming the safety of the 2013 guideline. Monitoring of the safety of a newly implemented guideline is of utmost importance and evaluation should be repeated continuously as neonatal policies are changing over time and may differ between countries. Therefore each country should evaluate its own ROP screening guideline repeatedly and if necessary modify it. Countries with comparable ROP populations to the Netherlands evaluated their guidelines recently: American guidelines were updated, New Zealand guidelines remained unchanged and modifications of the Swedish guidelines were proposed based on 10 year data from the Swedish register [23–25].

The decrease in population GA we found in our study is most likely a consequence of the policy change (2010), which lowered the age of

Table 2
Neonatal data of infants with VI caused by ROP in five consecutive periods.

	Period 1 1975–1987	Period 2 1986–1994	Period 3 1994–2000	Period 4 2000–2009	**Period 5 2009–2018**
No. infants	76	87	51	42	53
Male (%)*	47	58	59	74	51
Mean GA (weeks)†	28.7 ± 2.7	27.5 ± 2.5	27.7 ± 2.4	27.4 ± 2.0	26.6 ± 1.9
Mean BW (gram)‡	1128 ± 331	1071 ± 385	942 ± 306	912 ± 385	823 ± 323
Multiple birth (%)	19	21	31	31	28

* Gender cohort 4 vs. 5 $p = 0.056$ (Chi^2 Test).
† GA cohort 4 vs. 5 $p = 0.047$ (Mann Whitney U Test), 1 vs. 5 $p = 0.023$.
‡ BW cohort 4 vs. 5 $p = 0.349$ (Mann Whitney U Test), 1 vs. 5 $p = 0.003$.

Table 4
Proportion of infants with different categories of VA determined by vision of the best eye and absolute number of infants treated in period 5 in relation to visual outcome with the number of non-treated infants in brackets.
LP, light perception; ROP, retinopathy of prematurity; VA, visual acuity.

	Period 1 1975–1987	Period 2 1986–1994	Period 3 1994–2000	Period 4 2000–2009	Period 5 2009–2018	*p* 4 vs. 5	**Treated Period 5 (*n*)**
Inclusion (years)	13	9	7	9	9		
No. Infants *n*	76	87	51	42	53		
VA per category % (*n*)							
Unspecified	5.1 % (4)	–	–	–	3.8 % (2)	0.243	2 (0)
Not partially sighted or blind (VA > 0.3)[a]	2.0 % (2)	10.3 % (9)	9.8 % (5)	23.8 % (10)	35.8 % (19)	0.109	10 (9)
Partially sighted (VA 0.1–0.3)	34.3 % (26)	31.0 % (27)	25.5 % (13)	38.1 % (16)	30.2 % (16)	0.372	11 (5)
Socially blind (VA < 0.1–1/60)	12.1 % (9)	10.3 % (9)	11.8 % (6)	14.3 % (6)	9.4 % (5)	0.355	4 (1)
Practically blind (VA < 1/60-LP)	8.1 % (6)	21.8 % (19)	25.5 % (13)	16.7 % (7)	5.7 % (3)	0.119	2 (1)
Completely blind (VA = 0)	38.4 % (29)	26.4 % (23)	27.5 % (14)	7.1 % (3)	15.1 % (8)	0.119	6 (2)
ROP treatment (%)	24.4	43.9	56.9	66.7	66.0	0.529	35

[a] Including infants with unilateral blindness. Period 5: $n = 3$ (11.8 %).

Table 5
Concomitant disabilities in infants with visual impairment caused by ROP in five consecutive periods in the Netherlands (%). (*p*-value chi-square test).
Definitions. BPD (bronchopulmonary dysplasia): the need for supplemental oxygen at 28 days of life; Behavioral Abnormalities: according to the Diagnostic and Statistical Manual of mental disorders; Hearing Deficit: bilateral hearing loss ≥40 dB; Developmental Delay: >6 months disparity with a comparable age group with no improvement in relation to earlier assessment, according to the Dutch adaptation of the Reynell-Zinkin developmental scales for visually handicapped children; Neurological handicap (defined as treated hydrocephalus, posthemorrhagic ventricular dilatation, cerebral palsy and cerebral visual impairment); Multiple Disabled: VI caused by ROP and one or more concomitant disabilities, excluding BPD as quality of life improves in adolescence and young adulthood.

	Period 1 1975–1987	Period 2 1986–1994	Period 3 1994–2000	Period 4 2000–2009	**Period 5 2009–2018**	***p*** **4 vs. 5**
No. infants	76	87	51	42	53	
BPD	26.3	45.9	60.4	76.2	71.7	0.621
Behavioral abnormalities	9.2	21.8	46.9	40.0	26.4	0.092
Epilepsy	5.3	6.9	16.3	0	7.5	0.157
Hearing deficit	5.3	2.3	8.2	12.5	5.7	0.157
Developmental delay	35.5	47.1	52.9	65.0	69.8	0.933
Neurological handicaps	30.3	49.4	45.1	42.5	30.2	0.621
Multiple disabled	39.5	58.6	68.2	66.7	75.5	0.935

Table 6
Visual impairment (VI) caused by ROP in relation to estimated number of survivors and percentage of infants with concomitant disabilities in patients with VI, both in relation to GA.

GA (weeks)	VI caused by ROP %(*n*)[a]					Concomitant disabilities %(*n*)	
	Period 1 '75–'87	Period 2 '86–'94	Period 3 '94–'00	Period 4 '00–'09	Period 5 '09–'18	Period 4 '00–'09	Period 5 '09–'18
23	–	–	–	–	6.25 (1)	–	100 (1)
24–25	10.4 (11)	12.5 (11)	3.1 (9)	2.4 (10)	2.1 (21)	69 (7)	81 (17)
26–27	3.3 (40)	4.3 (36)	1.3 (23)	0.9 (19)	0.7 (18)	79 (15)	89 (16)
28–29	0.8 (26)	0.4 (10)	0.3 (10)	0.2 (9)	0.2 (8)	78 (7)	100 (8)
30–31	0.2 (13)	0.2 (8)	0.1 (6)	0.03 (2)	0.05 (5)	50 (1)	60 (3)
>32–<37	0.01 (12)	0.01 (7)	<0.001 (2)	<0.002 (2)	–	50 (1)	–
Total	102	72	50	42	53	73.8 (31)	84.9 (45)

[a] Numbers of estimated survivors obtained from the Netherlands Perinatal Registry.

active neonatal treatment for extreme preterm infants. Since the previous period (period 4) a >3-fold increase in live births with GA < 25.0 weeks was observed. As expected and corresponding to the previous Dutch periods, the largest number of infants with visual impairment due to ROP was in infants with the lowest GA. Moreover, since 2014, higher, and in regard to ROP more unfavorable, oxygen saturation targets were accepted in most Dutch NICUs. For (retinal) blood vessel development hyperoxic circumstances in the first weeks of life are detrimental, because they can lead to arrest of angiogenesis and obliteration of already developed vessels. Thus, together with the higher survival of extremely preterm infants, the incidence of sROP was expected to increase accordingly. A recent retrospective study on ROP treatment the Netherlands confirmed this concern: twice as many infants were treated for ROP in the period 2013–2016 compared to 2010–2013 [3,4].

Fortunately, we did not observe an analogous increase in visual impairment: 32/53 (60.4 %) infants became visually disabled representing a nonsignificant decrease since period 4 (32/42, 76.2 %, $p = 0.103$). Also among overall live births in the Netherlands, the rate was similar to the last period (Table 3). Thus, despite unfavorable neonatal factors, the incidence of visual impairment due to ROP remained relatively stable. Nevertheless, future inventories are of importance to determine no further ROP sequelae due to this policy change, especially considering that in the last cohort (period 5, 2009–2018), only half of the group was born after 2014.

Most infants were treated with laser. Only two were treated with anti-VEGF, which can be attributed to the low number of infants with ROP in zone I, being the criterion for this treatment following the Dutch guideline. The number of untreated infants in the present period remained unchanged (34.0 %) compared to the previous (33.3 %). Respectively nine (17.0 %) and eight (19.0 %) of them became visually

impaired.

The proportion of children with visual impairment developing at least one nonvisual disability increases with decreasing GA (Table 6). The association of prematurity and neurodevelopmental disabilities has previously been widely described [26–29], as well as the correlation between severity of ROP and neurodevelopment [30]. Several studies discuss that the possible cause of sROP and decreased brain development may be the same, namely IGF-1 deficiency, and that both disorders therefore may be correlated with one another. Low IGF-1 concentration levels following preterm birth suppress retinal vessel outgrowth and restoration, contributing to both phases of ROP [31–33]. IGF-1 is also essential for the developing brain, i.e. axon maturation, myelinization of the brainstem and development of cerebellar neurons [34]. Another explanation for a possible relationship between sROP and brain injury may be that during admission on the NICU preterm infants are extensively exposed to adverse events that all have negative effects on both the developing retina and brain. Glass et al. presented delayed white matter maturation and lower cognitive and motor scores in infants with sROP compared to those without [35]. However, no significant differences in the rate of cerebral palsy, hearing or visual impairment were found. Two studies, by Drost et al. and Sveinsdóttir et al., using magnetic resonance imaging show an association between (severe) ROP and significantly smaller white matter and cerebellar and brainstem volumes for which in both conditions a deficiency in the insulin-like growth factor protein is presumably responsible [36,37]. Moreover, both studies report on poorer outcome in infants who have developed (severe) ROP. The risk for developmental delay remains high, even in children born moderately preterm. In our cohort, we also observed a trend toward less infants with cerebral palsy and/or behavioral abnormalities, however the overall prevalence of nonvisual disabilities has not changed significantly since the last period and neither did the number of infants with at least one or more concomitant disability (Tables 5 and 6).

We compared the Dutch ROP data to several studies from other countries. A global overview of visual impairment due to ROP in 2010 was presented by Blencowe et al. in which the incidence of visual impairment in high income countries was estimated 14.5 per 100.000 live births [1]. In a large Swedish cohort, a much lower incidence was presented of 1.3 per 100.000 live births from 2004 to 2015 [24]. Contrary to our study however, the Swedish data were collected prospectively and moreover, strict inclusion criteria applied: all infants born in a foreign country or with potential other causes of visual impairment than ROP (among which cerebral visual impairment) were excluded. If our criteria would apply to the Swedish cohort, the incidence would increase to 3.3 per 100.000 births. A study from New Zealand was, correspondingly to ours, based on retrospective data from a national registry for blind and low vision children. Over the 22-year study period, 2.8 per 100.000 new-born infants became visually impaired due to ROP [38]. Moreover, a notable decrease in visual impairment was found since the implementation of the ETROP treatment criteria in 2005, from 3.4 to 1.8 per 100.000 births.

Treatment of ROP was comparable to the New-Zealand study, in which 22.2 % of infants with visual impairment due to ROP were not treated [38]. In the Swedish inventory, only 5.9 % was untreated, however it was identified that in 35.3 % of the population, visual impairment was avoidable because treatment was performed untimely or suboptimal [24]. It therefore cannot be emphasized enough that timely identification of treatment warranting ROP stages is essential to allow further decrease in the incidence of visual impairment due to ROP. For this, ongoing surveillance and monitoring of national guidelines is necessary.

It is challenging to compare the incidence of visual impairment caused by ROP, to the incidence in other countries due to different study designs and accessibility of data. By combining the results from the past 3 Dutch periods into a 24-year period, we find a comparable 2.4 per 100.000 incidence in the Netherlands (Table 3). Overall, our five Dutch periods demonstrate a gradual decrease in visual disability due to ROP over the past three decades and a slight but nonsignificant increase since 2009.

Main limitations of our study include the retrospective study design and newly introduced strict privacy laws (GDPR), which made it challenging to obtain more detailed data on neonatal risk factors or the course of ROP. Of the two infants with unknown VA it was not possible to determine if data were missing or if they were too young to assess VA. Furthermore, it is possible that there are infants who are not yet referred to the institutes. Therefore, the visual impairment incidence found in this inventory should be considered a minimum and ongoing future surveillance is necessary. Yet, the institutes are well known among Dutch ophthalmologists and they provide easy access for referral. It therefore is likely that the data from this study give a valid representation of visual impairment due to ROP in the Netherlands.

In conclusion, this study emphasizes the necessity for periodic evaluation of ROP guidelines and long term surveillance of outcome parameters in prematurely born infants. In the Netherlands no infants were missed for screening based on the new inclusion criteria, illustrating the safety of the national ROP guideline. Despite improvements in neonatal care, the number of infants with concomitant disabilities did not change. Visual impairment due to ROP remained low despite a lower GA and higher oxygen saturation targets.

CRediT authorship contribution statement

K. Trzcionkowska: investigation, funding acquisition, formal analysis, writing – original draft, writing review & editing; **J.U.M. Termote**: writing review & editing; **M.M. van Genderen**: recourses, writing review & editing; **M.J. de Vries**: recourses, writing review & editing; **A.J. van Sorge**: recourses, writing review & editing; **N.E. Schalij-Delfos**: supervision, writing review & editing.

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Declaration of competing interest

The authors declare that there is no conflict of interest.

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