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Survival Rates and Improvement Measures: Differences in Causes of Death in Preterm versus Term Neonates in Soweto, South Africa

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Introduction

Prematurity remains a **major contributor to neonatal and infant mortality** in sub-Saharan Africa.

The specific causes of death and pathogens involved are **not well characterised.**

Understanding these mortality pathways can help identify **preventable deaths** and **targeted interventions.**

About CHAMPS

CHAMPS

What We Stand For

The CHAMPS Promise

CHAMPS transforms data into action, working at the local, national and global levels to ensure sustainable changes in policies, systems, and health interventions to accelerate improvements in child health.



Reducing Child Mortality

Our data catalyzes evidence-driven interventions that can save the lives of millions of children.



Building Local Capacity

CHAMPS works with communities, ministries of health and national public health institutes to strengthens local health and science capacity.



Data to Action

CHAMPS transforms data into action, working with partners to use our findings to inform interventions that address under-five mortality.



Data Sharing

Our open-access data sharing and diverse, multi-sectoral partnerships drive evidence-based interventions.

OBJECTIVE



The objective of this analysis was to describe differences in causes of death between **preterm (<37 weeks gestation)** and **term (≥37 weeks gestation)** neonates enrolled in the CHAMPS MITS project in Soweto, South Africa between 2016 and 2025.

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Methods

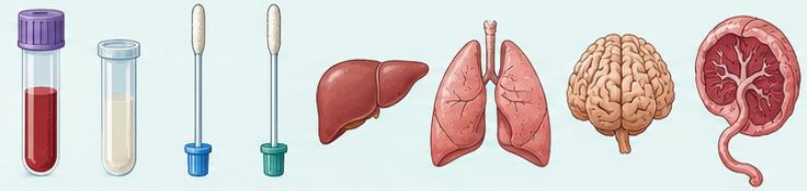
Methods

CHAMPS generates rigorous child mortality data through a structured, multi-step process from death identification to laboratory confirmation and expert cause-of-death determination.

01 Stage 1 Data Collection

- Deaths identified within 72 hours
- Parental consent
- Family interviews via verbal autopsy
- Clinical records review

02 Stage 2 Examination & Sample Collection



Clinical examination, photographs and physical measurements

03 Stage 3 Laboratory Testing

- Bacterial culture
- Rapid tests (e.g. HIV, TB, Malaria)
- PCR / molecular tests
- Pathology tissue examination

04 Stage 4 Cause of Death Determination

- Expert panel review
- Data integration and analysis
- CHAMPS insights and reporting

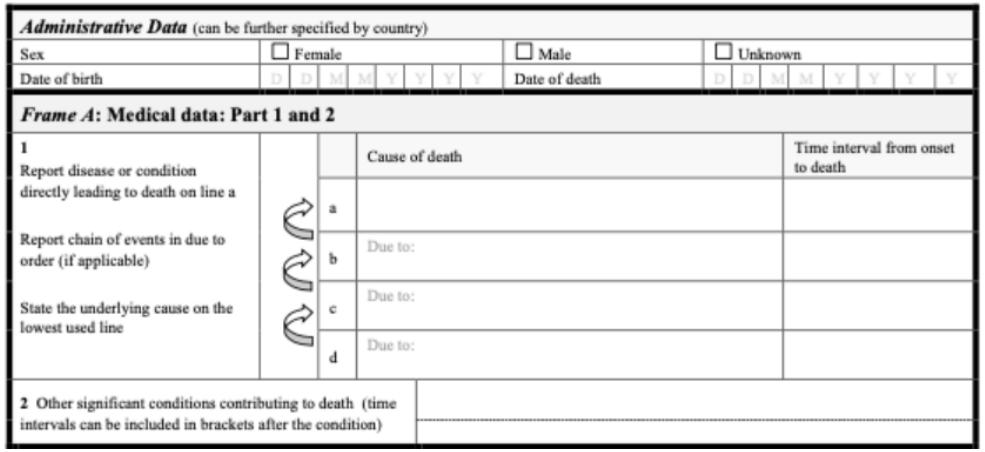
Coding Causal Pathway to Death - WHO

Administrative Data (can be further specified by country)															
Sex	☐ Female								☐ Male				☐ Unknown			
Date of birth	D	D	M	M	Y	Y	Y	Y	Date of death	D	D	M	M	Y	Y	Y	Y

***Frame A*: Medical data: Part 1 and 2**				
1 Report disease or condition directly leading to death on line a Report chain of events in due to order (if applicable) State the underlying cause on the lowest used line			Cause of death	Time interval from onset to death
		a		
		b	Due to:	
		c	Due to:	
		d	Due to:	
2 Other significant conditions contributing to death (time intervals can be included in brackets after the condition)				

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Coding Causal Pathway to Death - WHO



Administrative Data (can be further specified by country)

Sex	☐ Female	☐ Male	☐ Unknown
Date of birth	D D M M Y Y Y Y	Date of death	D D M M Y Y Y Y

***Frame A*: Medical data: Part 1 and 2**

1		Cause of death	Time interval from onset to death
Report disease or condition directly leading to death on line a	a		
Report chain of events in due to order (if applicable)	b	Due to:	
State the underlying cause on the lowest used line	c	Due to:	
	d	Due to:	

2 Other significant conditions contributing to death (time intervals can be included in brackets after the condition)	

1. **Report the disease or condition directly leading to death**
   (on line a)
2. **Report the chain of events in due order**
   (if applicable, on lines b, c, d)
3. **State the underlying cause of death**
   (on the lowest used line, e.g. a, b, c or d)
4. **Report other significant conditions contributing to death**
   (time intervals can be included in brackets after the condition)

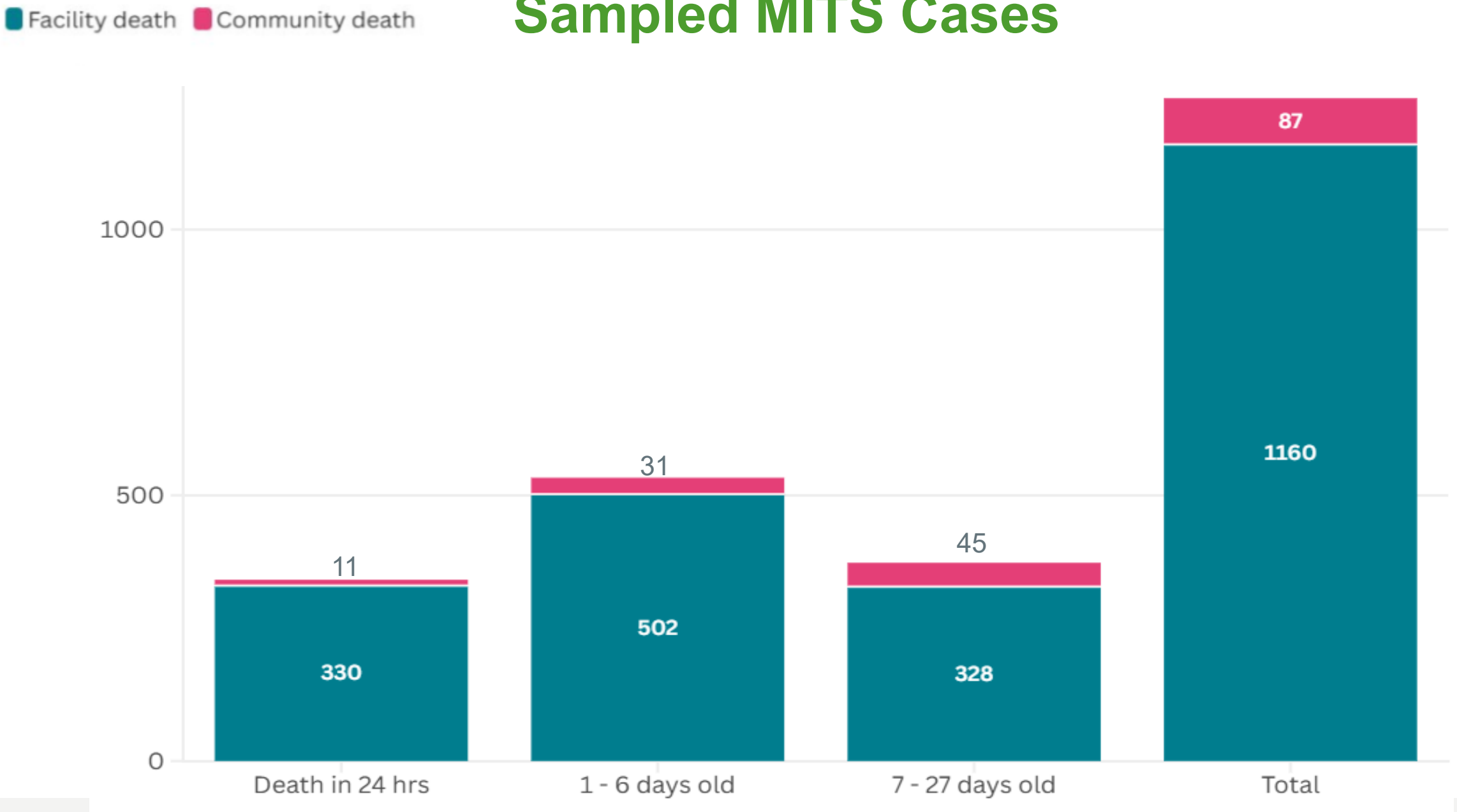
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Results

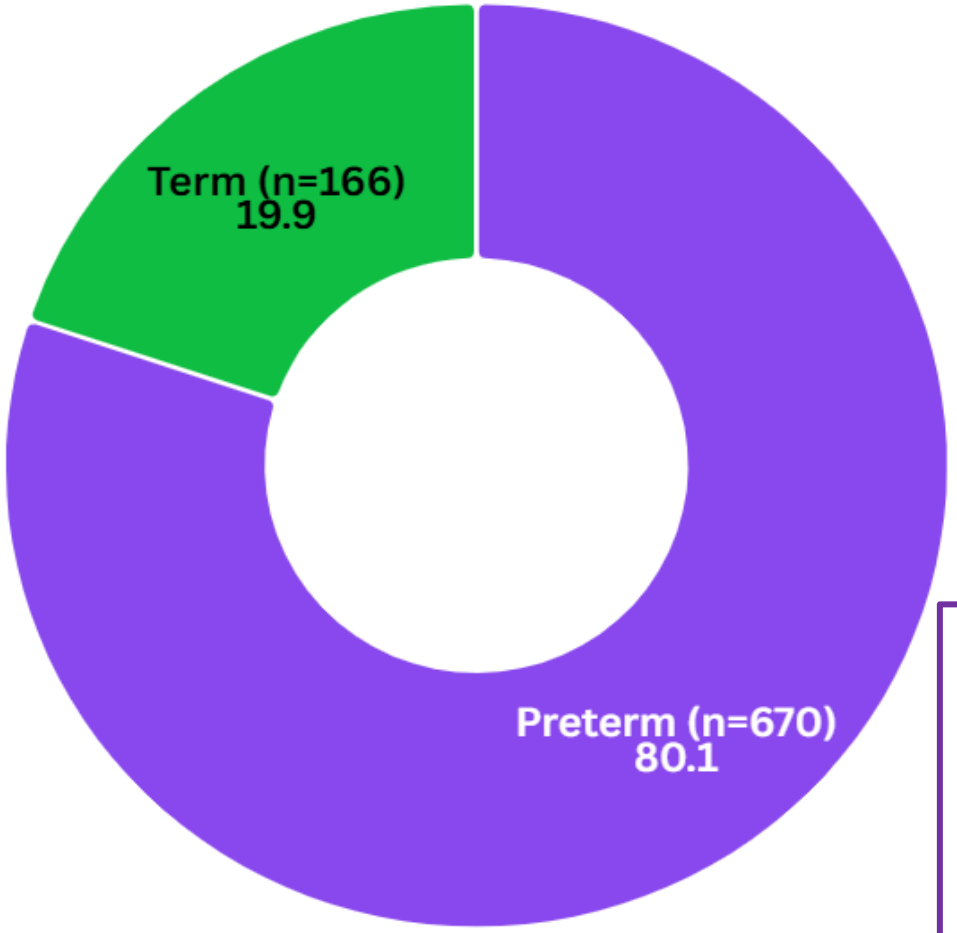
Sampled MITS Cases



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Gestational Age of Sampled Cases

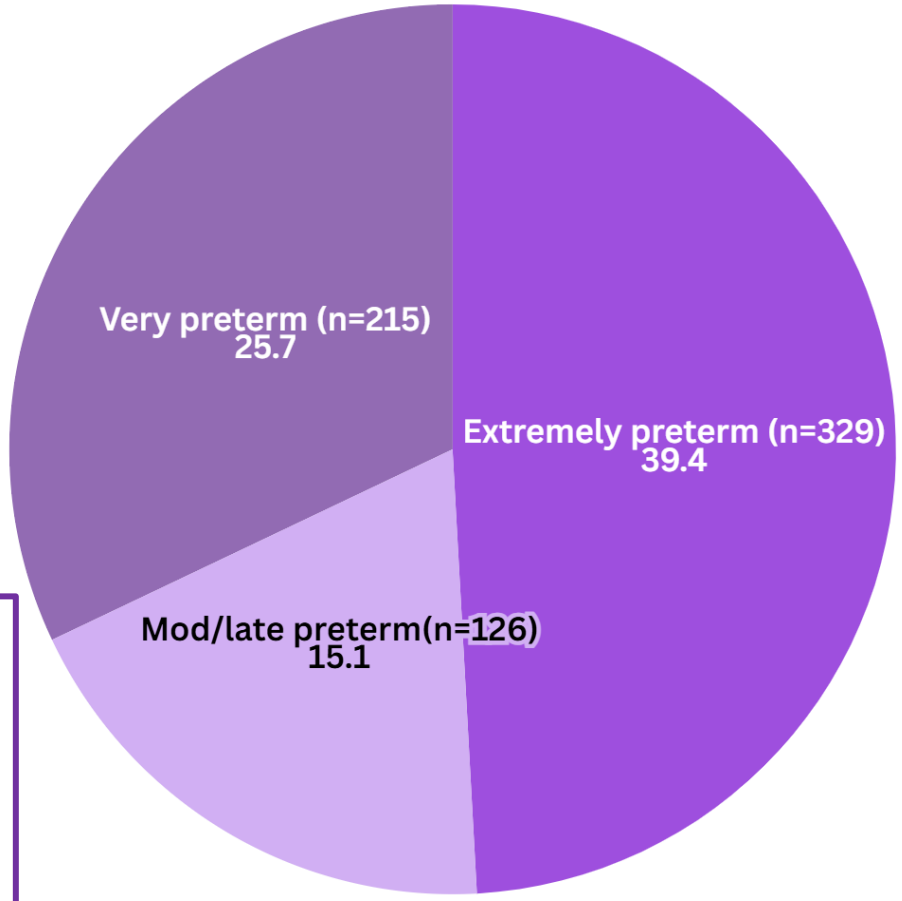
Premature Vs Term (%)



Gestational Age Categories (WHO)

Extremely preterm: <28 weeks
Very preterm: 28 to <32 weeks
Moderate-to-late preterm: 32 to <37 weeks
Term: ≥37 weeks

Categories of prematurity (%)



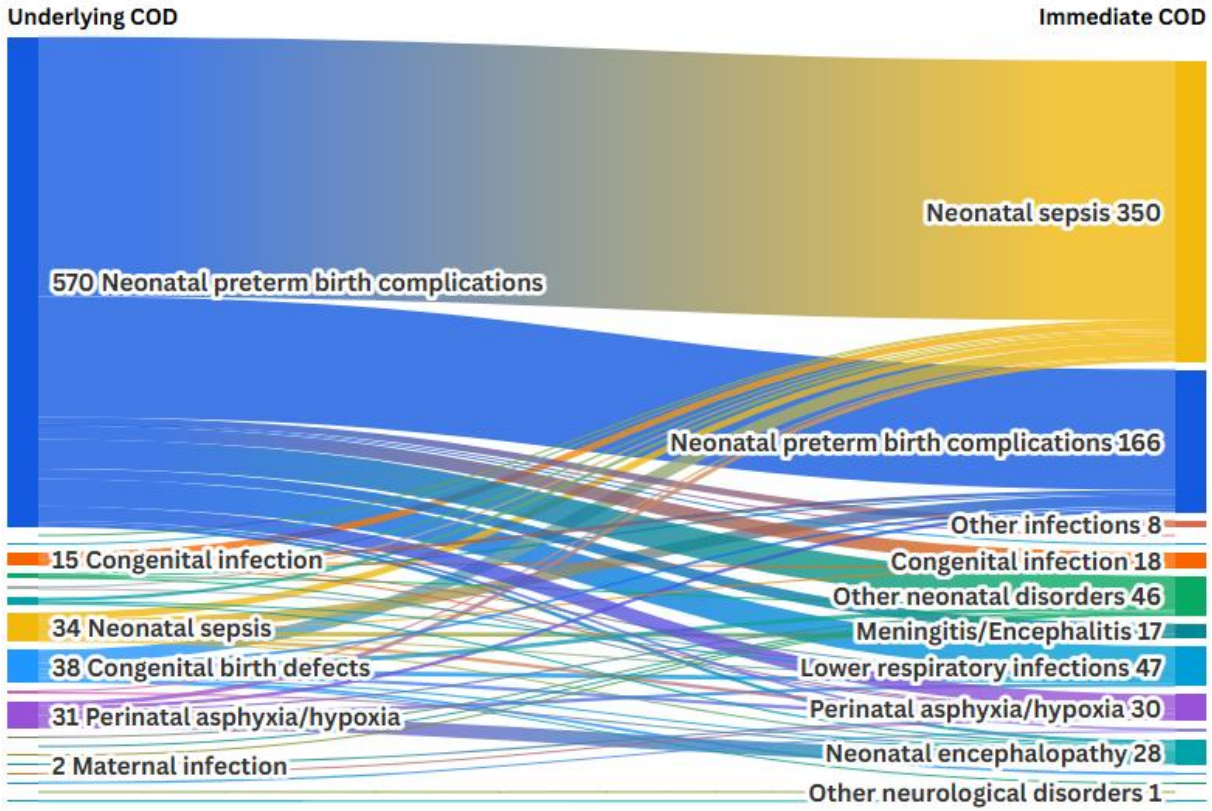
Characteristics of Included Neonates

Characteristic	Category	Term (n=166)	Preterm (n=670)	Total (n=836)
Location of death	Community	2 (1,2%)	4 (0,6%)	6 (0,7%)
HIV*	**Exposed**	**41 (24,7%)**	**240 (35,8%)**	**280 (33,6%)**
Sex	Male	87 (52,4%)	395 (59,0%)	482 (57,7%)
Mode of delivery	C-section	71 (42,8%)	286 (42,7%)	357 (42,7%)
Admission	Never discharged	152 (91,6%)	653 (97,5%)	805 (96,3%)

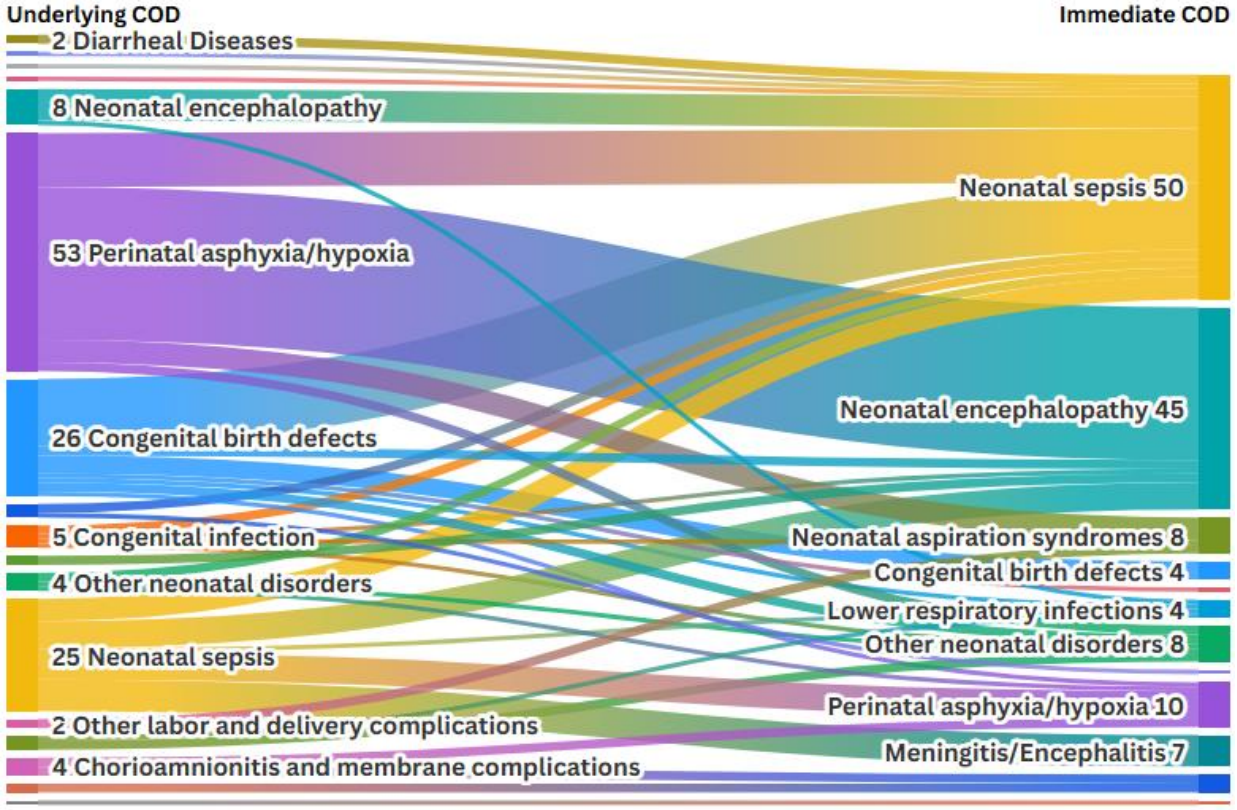
*indicates significant difference at p-value<0,05
Where data not available for all MITS cases percentages were calculated only among cases with known values

Causes of Death

Preterm



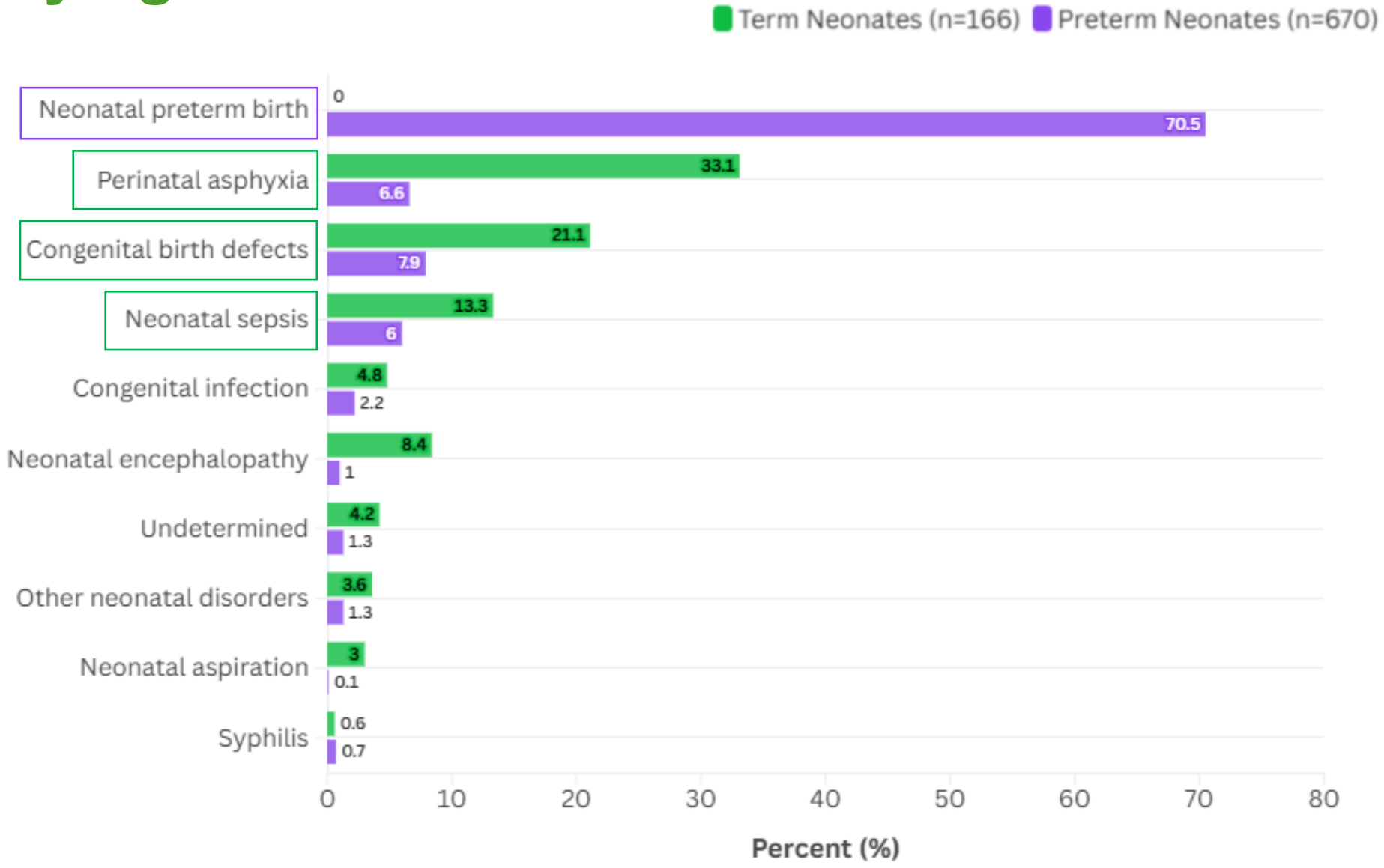
Term



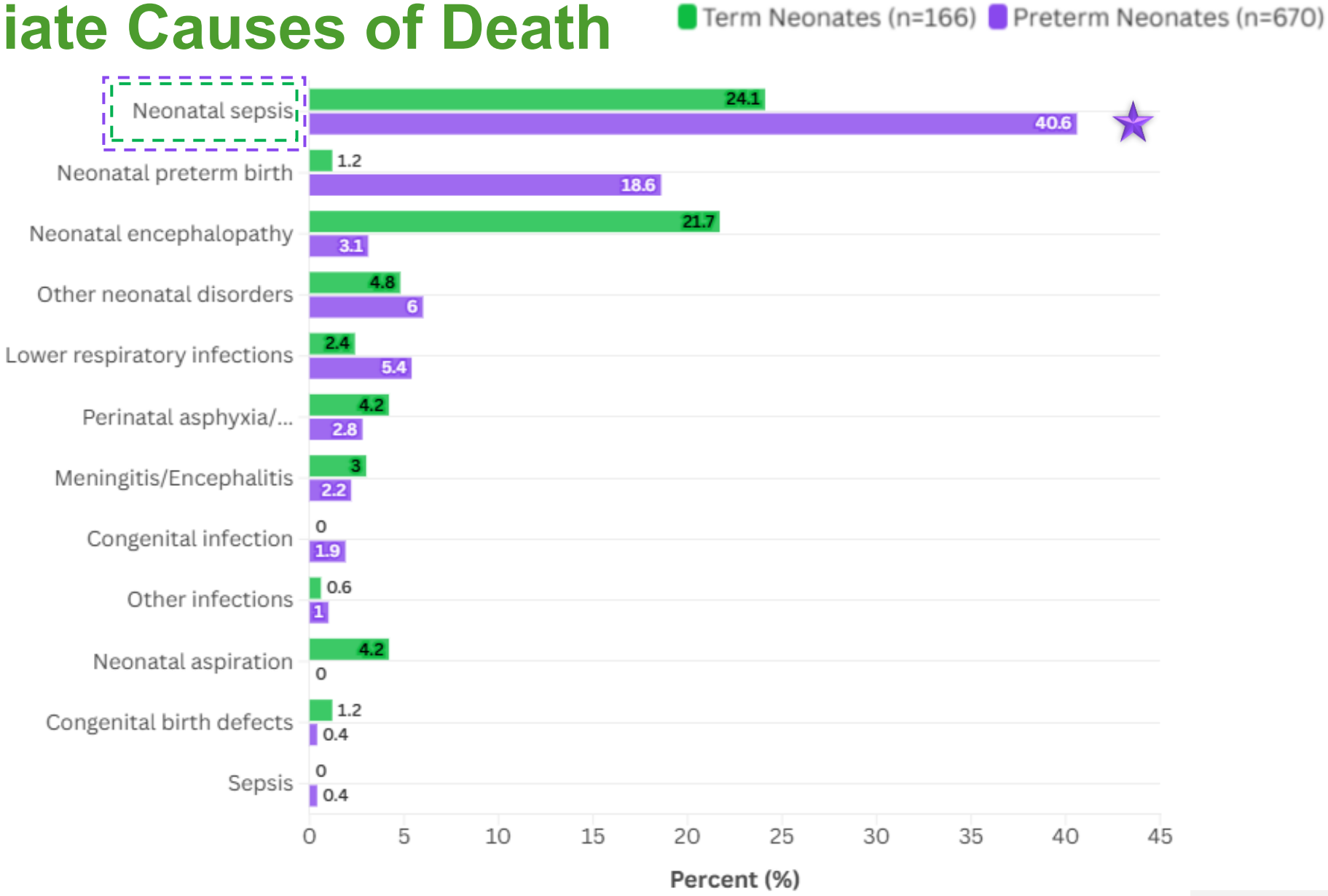
Scan here for an interactive version of these diagrams

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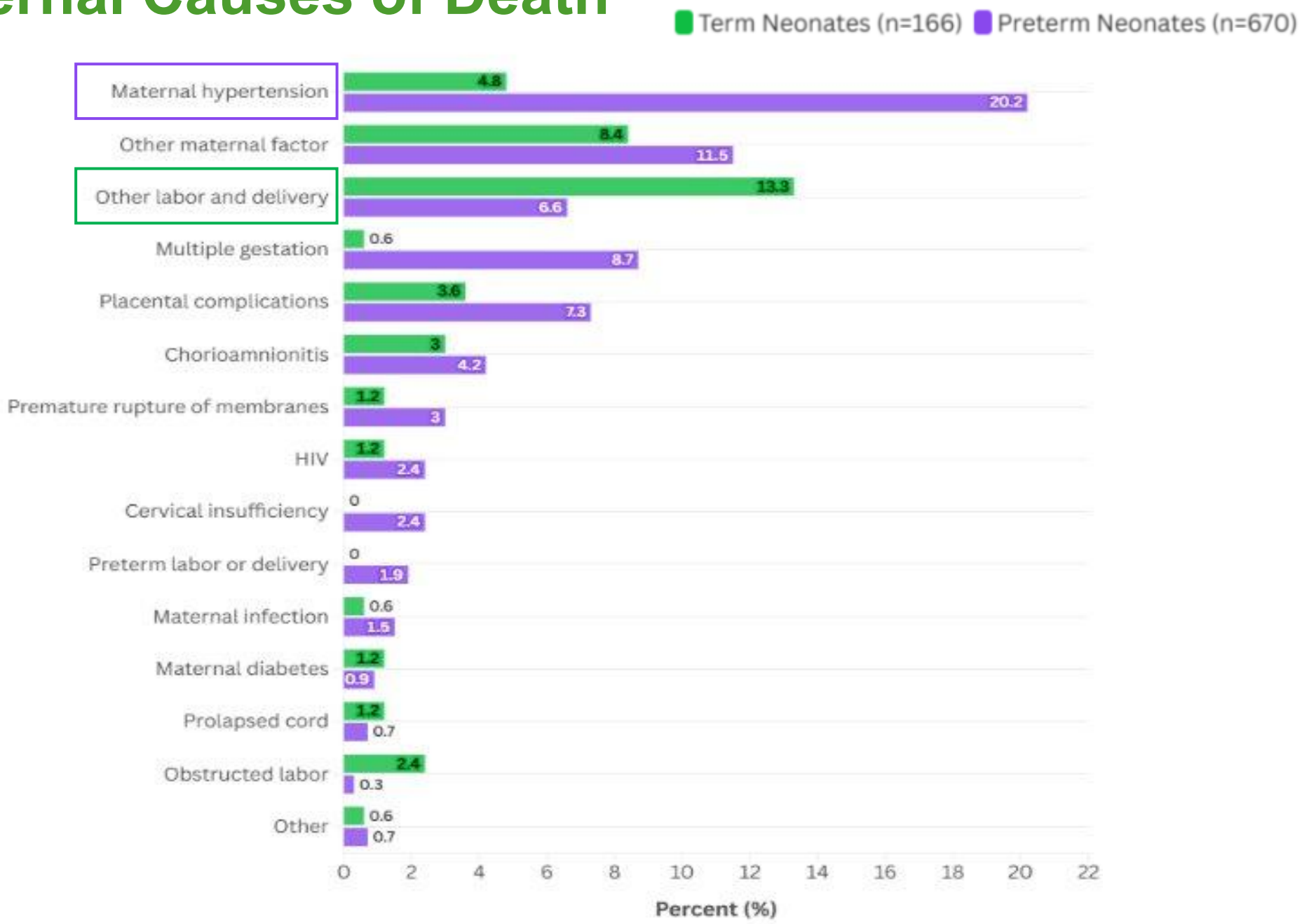
Underlying Causes of Death



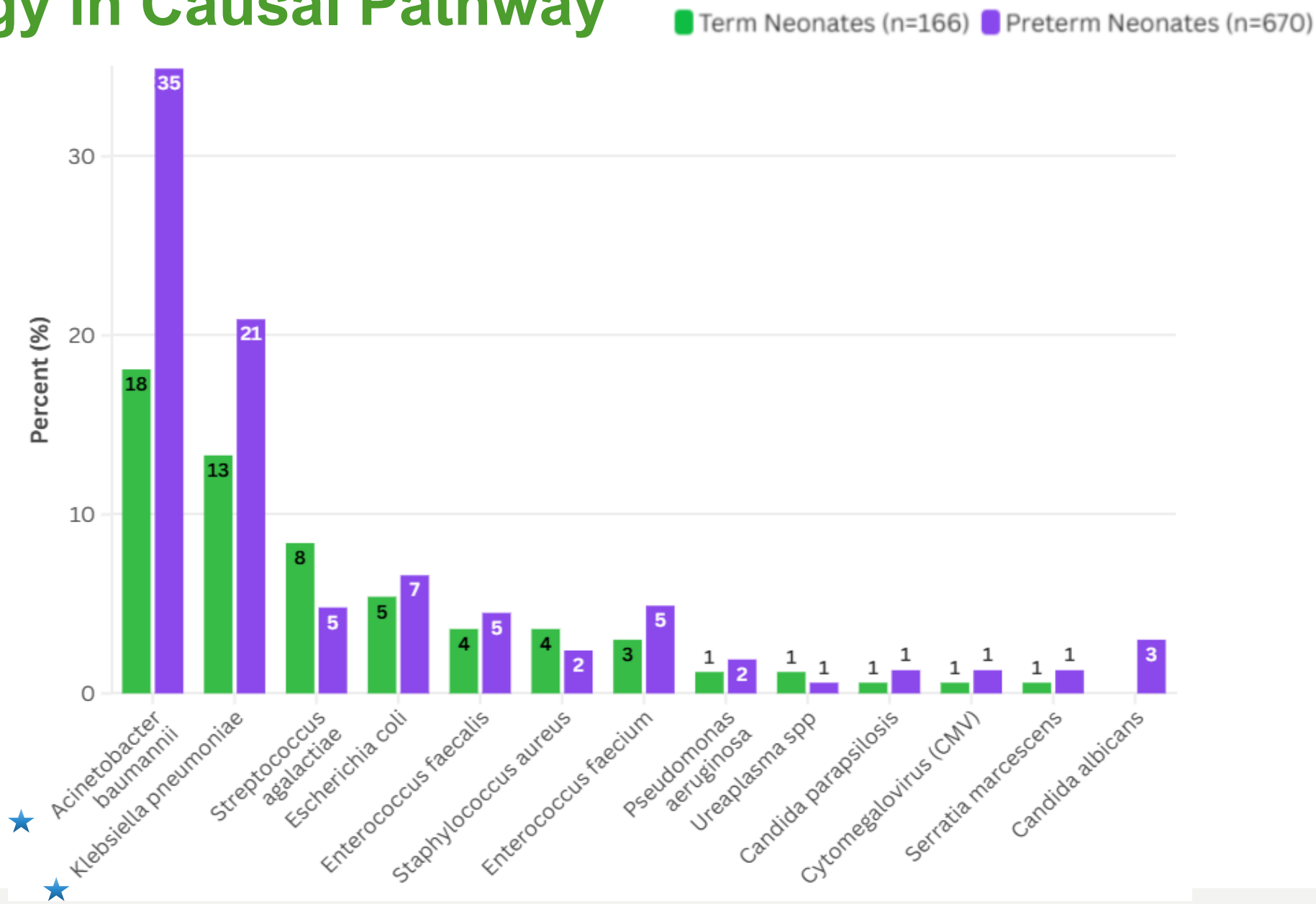
Immediate Causes of Death



Main Maternal Causes of Death



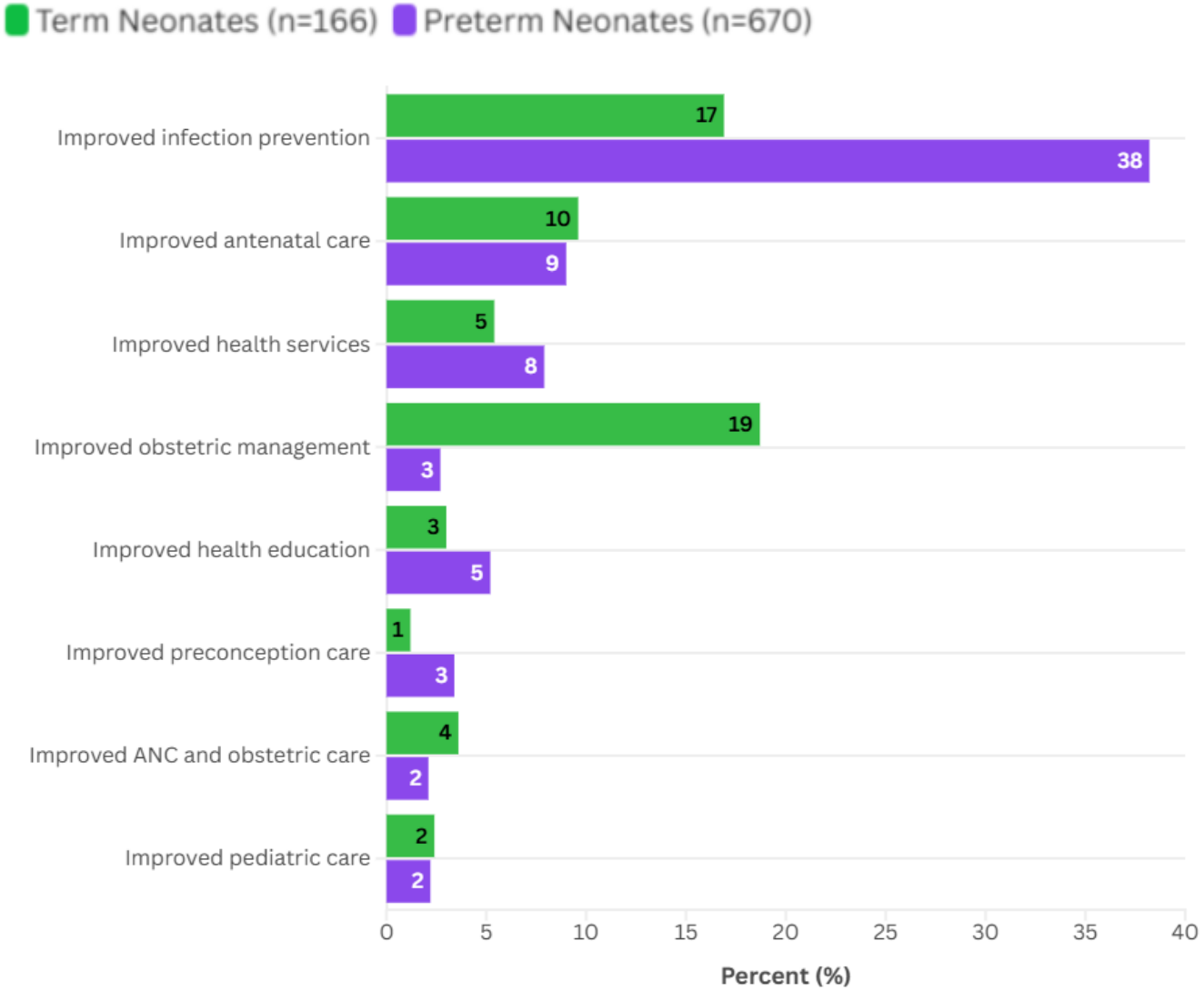
Etiology in Causal Pathway

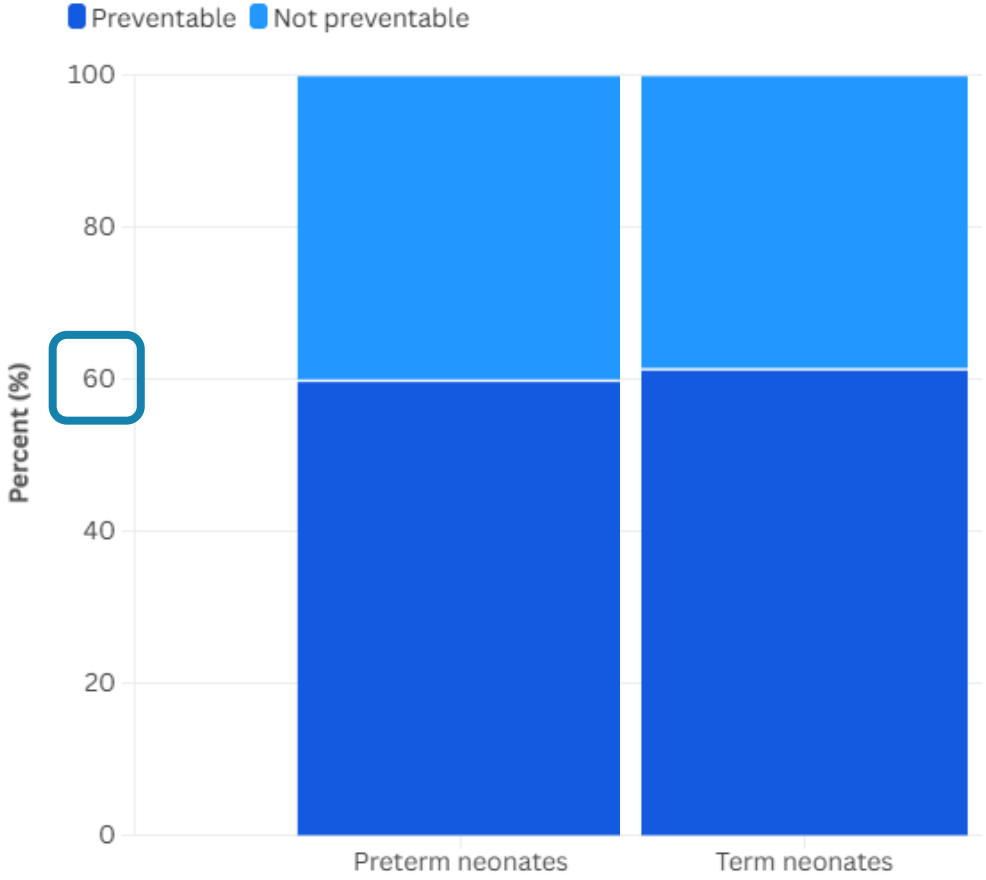


*a case may have multiple pathogens in the causal pathway

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Preventability





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*Multiple categories allowed per case

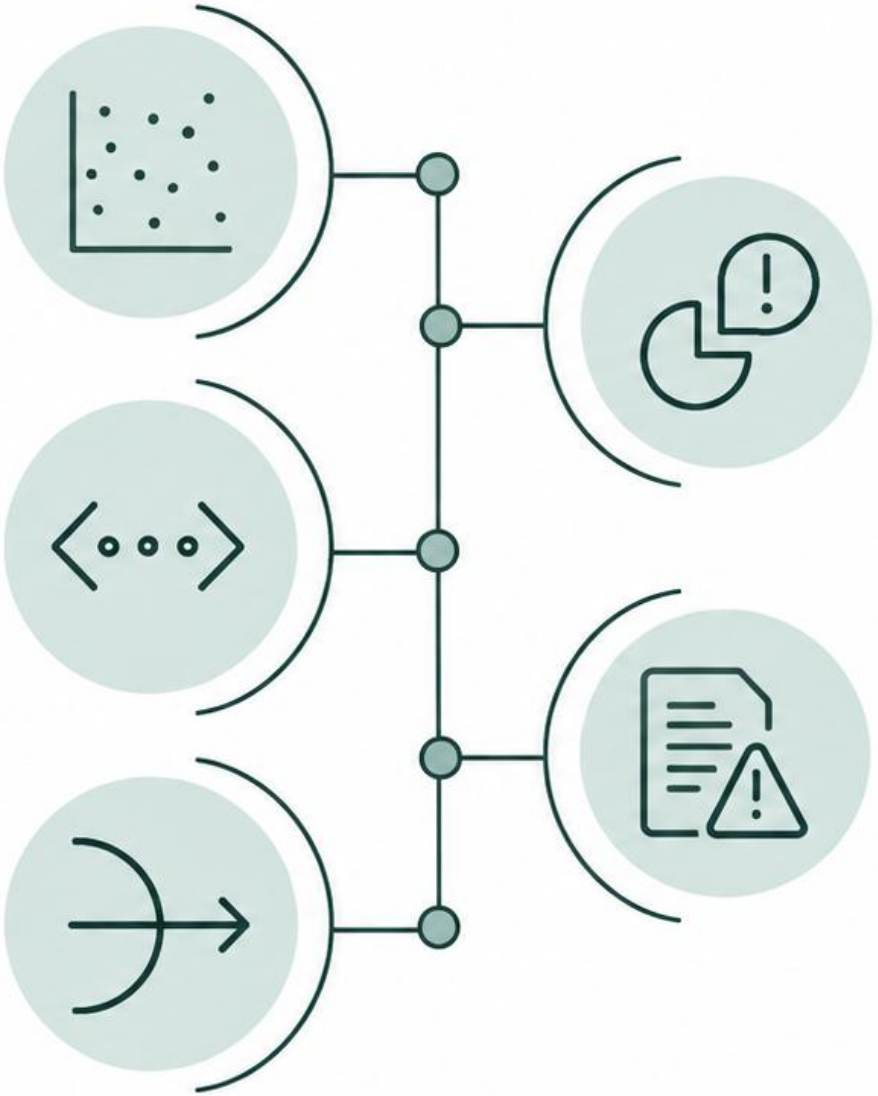
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Study Limitations

No Control Group

Historical ICD coding limited identification of specific prematurity-related complications.

Further analysis should explore IUGR and SGA in term and preterm neonates.



GA was missing in 408/1,244 neonates (32.8%), primarily community deaths; these cases were excluded, limiting community death representation.

GA based on hospital records; documentation error possible.

Conclusions



1. Prematurity was a leading driver of mortality

80.1% of enrolled neonatal deaths were preterm, with many born extremely preterm (<28 weeks).



2. Causes of death differed by gestational age

Prematurity-related complications predominated among preterm neonates, while term neonates had a broader range of infectious and congenital causes in the overall pathway.



3. Infection and maternal factors remained important

Key pathogens included *Klebsiella pneumoniae, Acinetobacter baumannii* and *Escherichia coli*; maternal hypertension was the leading maternal condition associated with neonatal deaths.



4. Clear opportunities for prevention exist

Priority interventions include improved infection prevention and control, earlier healthcare-seeking behaviour, and strengthened antenatal care.



5. HIV exposure was more common in the preterm group[1]

This pattern was more frequent among preterm than term neonates.

Reducing neonatal mortality requires a dual focus on preventing prematurity and strengthening the prevention and management of infections and maternal complications.

[1]Xiao, Peng-Lei, Yi-Biao Zhou, Yue Chen, Mei-Xia Yang, Xiu-Xia Song, Yan Shi, and Qing-Wu Jiang. 2015. "Association between Maternal HIV Infection and Low Birth Weight and Prematurity: A Meta-Analysis of Cohort Studies." *BMC Pregnancy and Childbirth* 15:246. doi:10.1186/s12884-015-0684-z.

Acknowledgements

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SCIENTIFIC CONTRIBUTIONS
Panellists and Collaborators.

STUDY PARTICIPANTS
and their relatives.

Scan to follow the CHAMPS South Africa Facebook page

Scan to see for Sankey diagram showing underlying to immediate links

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Underlying Causes of Death

	Term (n=166)	Preterm (n=670)	Total (n=836)
Neonatal preterm birth	0 (0.0%)	470 (70.1%)	470 (56.2%)
Perinatal asphyxia/hypoxia	55 (33.1%)	44 (6.6%)	99 (11.8%)
Congenital birth defects	35 (21.1%)	53 (7.9%)	88 (10.5%)
Neonatal sepsis	22 (13.3%)	40 (6.0%)	62 (7.4%)
Congenital infection	8 (4.8%)	15 (2.2%)	23 (2.8%)
Neonatal encephalopathy	14 (8.4%)	7 (1.0%)	21 (2.5%)
Undetermined	7 (4.2%)	9 (1.3%)	16 (1.9%)
Other neonatal disorders	6 (3.6%)	9 (1.3%)	15 (1.8%)
Neonatal aspiration	5 (3.0%)	1 (0.1%)	6 (0.7%)
Syphilis	1 (0.6%)	5 (0.7%)	6 (0.7%)
Chorioamnionitis and related	2 (1.2%)	3 (0.4%)	5 (0.6%)

Immediate Causes of Death

	Term (n=166)	Preterm (n=670)	Total (n=836)
Neonatal sepsis	40 (24,1%)	271 (40,4%)	311 (37,2%)
Neonatal preterm birth	2 (1,2%)	124 (18,5%)	126 (15,1%)
Neonatal encephalopathy	36 (21,7%)	21 (3,1%)	57 (6,8%)
Other infections	8 (4,8%)	40 (6,0%)	48 (5,7%)
Lower respiratory infection	4 (2,4%)	36 (5,4%)	40 (4,8%)
Other respiratory disorders	7 (4,2%)	19 (2,8%)	26 (3,1%)
Meningitis/Encephalitis	5 (3,0%)	15 (2,2%)	20 (2,4%)
Congenital infection	0 (0,0%)	13 (1,9%)	13 (1,6%)
Neonatal aspiration	7 (4,2%)	0 (0,0%)	7 (0,8%)
Congenital birth defects	2 (1,2%)	3 (0,4%)	5 (0,6%)
Perinatal asphyxia	3 (1,8%)	0 (0,0%)	3 (0,4%)
Sepsis	0 (0,0%)	3 (0,4%)	3 (0,4%)

Co-morbids

	Term (n=166)	Preterm (n=670)	Total (n=836)
Congenital birth defects	1 (0.6%)	10 (1.5%)	11 (1.3%)
Congenital infection	6 (3.6%)	13 (1.9%)	19 (2.3%)
Heart diseases	0 (0.0%)	1 (0.1%)	1 (0.1%)
Injury	0 (0.0%)	1 (0.1%)	1 (0.1%)
Kidney disease	3 (1.8%)	8 (1.2%)	11 (1.3%)
Liver disease	1 (0.6%)	1 (0.1%)	2 (0.2%)
Lower respiratory infection	25 (15.1%)	138 (20.6%)	163 (19.5%)
Meningitis/Encephalitis	11 (6.6%)	86 (12.8%)	97 (11.6%)
Neonatal aspiration	9 (5.4%)	2 (0.3%)	11 (1.3%)
Neonatal encephalopathy	9 (5.4%)	10 (1.5%)	19 (2.3%)
Neonatal preterm birth	7 (4.2%)	234 (34.9%)	241 (28.8%)
Neonatal sepsis	4 (2.4%)	57 (8.5%)	61 (7.3%)
Other	0 (0.0%)	2 (0.3%)	2 (0.2%)
Other disorders of development	1 (0.6%)	1 (0.1%)	2 (0.2%)
Other endocrine/metabolic	0 (0.0%)	1 (0.1%)	1 (0.1%)
Other infections	0 (0.0%)	9 (1.3%)	9 (1.1%)
Other neonatal disorders	17 (10.2%)	115 (17.2%)	132 (15.8%)
Other neurological disorders	0 (0.0%)	2 (0.3%)	2 (0.2%)
Other respiratory disorders	2 (1.2%)	4 (0.6%)	6 (0.7%)
Perinatal asphyxia/hypoxia	3 (1.8%)	13 (1.9%)	16 (1.9%)
Placental complications	0 (0.0%)	1 (0.1%)	1 (0.1%)

Main Maternal Causes of Death

Maternal Main Group	Term (n=166; %)	Preterm (n=670; %)	Total (n=836; %)
Maternal hypertension	8 (4.8%)	135 (20.1%)	143 (17.1%)
Other maternal factor	14 (8.4%)	77 (11.5%)	91 (10.9%)
Other labor and delivery	22 (13.3%)	44 (6.6%)	66 (7.9%)
Multiple gestation	1 (0.6%)	58 (8.7%)	59 (7.1%)
Placental complications	6 (3.6%)	49 (7.3%)	55 (6.6%)
Chorioamnionitis	5 (3.0%)	28 (4.2%)	33 (3.9%)
Premature rupture of membranes	2 (1.2%)	20 (3.0%)	22 (2.6%)
HIV	2 (1.2%)	16 (2.4%)	18 (2.2%)
Cervical insufficiency	0 (0.0%)	16 (2.4%)	16 (1.9%)
Preterm labor or delivery	0 (0.0%)	13 (1.9%)	13 (1.6%)
Maternal infection	1 (0.6%)	10 (1.5%)	11 (1.3%)
Maternal diabetes	2 (1.2%)	6 (0.9%)	8 (1.0%)
Prolapsed cord	2 (1.2%)	5 (0.7%)	7 (0.8%)
Obstructed labor	4 (2.4%)	2 (0.3%)	6 (0.7%)

Preventability

Recommendation	Term (n=166)	Preterm (n=670)	Total (n=839)
Improved infection prevention/control	28 (16.9%)	256 (38.2%)	284 (34.0%)
Improved antenatal care	16 (9.6%)	60 (9.0%)	76 (9.1%)
Improved health services	9 (5.4%)	53 (7.9%)	62 (7.4%)
Improved obstetric management	31 (18.7%)	18 (2.7%)	49 (5.9%)
Improved health education	5 (3.0%)	35 (5.2%)	40 (4.8%)
Improved preconception care	2 (1.2%)	23 (3.4%)	25 (3.0%)
Improved ANC and obstetric care	6 (3.6%)	14 (2.1%)	20 (2.4%)
Improved pediatric care	4 (2.4%)	15 (2.2%)	19 (2.3%)
Other recommendation	4 (2.4%)	11 (1.6%)	15 (1.8%)
Improved HIV prevention	2 (1.2%)	7 (1.0%)	9 (1.1%)
Improved family planning	0 (0.0%)	5 (0.7%)	5 (0.6%)
Improved clinical management	0 (0.0%)	4 (0.6%)	4 (0.5%)
Improved transport	0 (0.0%)	3 (0.4%)	3 (0.4%)
Address social issues	1 (0.6%)	6 (0.9%)	7 (0.8%)
Improved nutritional support	1 (0.6%)	0 (0.0%)	1 (0.1%)

Underlying COD by Discharged

Underlying Cause Group	Discharged after birth (n=25)	Never discharged after birth (n=1042)	Total* (n=1238)
Neonatal preterm birth	7 (28.0%)	589 (56.5%)	635 (51.3%)
Perinatal asphyxia/hypoxia	0 (0.0%)	133 (12.8%)	140 (11.3%)
Congenital birth defects	1 (4.0%)	110 (10.6%)	118 (9.5%)
Neonatal sepsis	10 (40.0%)	72 (6.9%)	113 (9.1%)
Neonatal encephalopathy	0 (0.0%)	32 (3.1%)	34 (2.7%)
Congenital infection	0 (0.0%)	25 (2.4%)	30 (2.4%)
Umbilical cord complications	1 (4.0%)	21 (2.0%)	55 (4.4%)
Undetermined	1 (4.0%)	21 (2.0%)	55 (4.4%)
Other neonatal disorders	1 (4.0%)	20 (1.9%)	25 (2.0%)
Meningitis/Encephalitis	1 (4.0%)	3 (0.3%)	6 (0.5%)
Chorioamnionitis and related	0 (0.0%)	5 (0.5%)	5 (0.4%)
Other infections	2 (8.0%)	1 (0.1%)	7 (0.6%)

*Total not addition of discharged and never discharged as there were some with unknown admission details

Immediate COD by Discharged

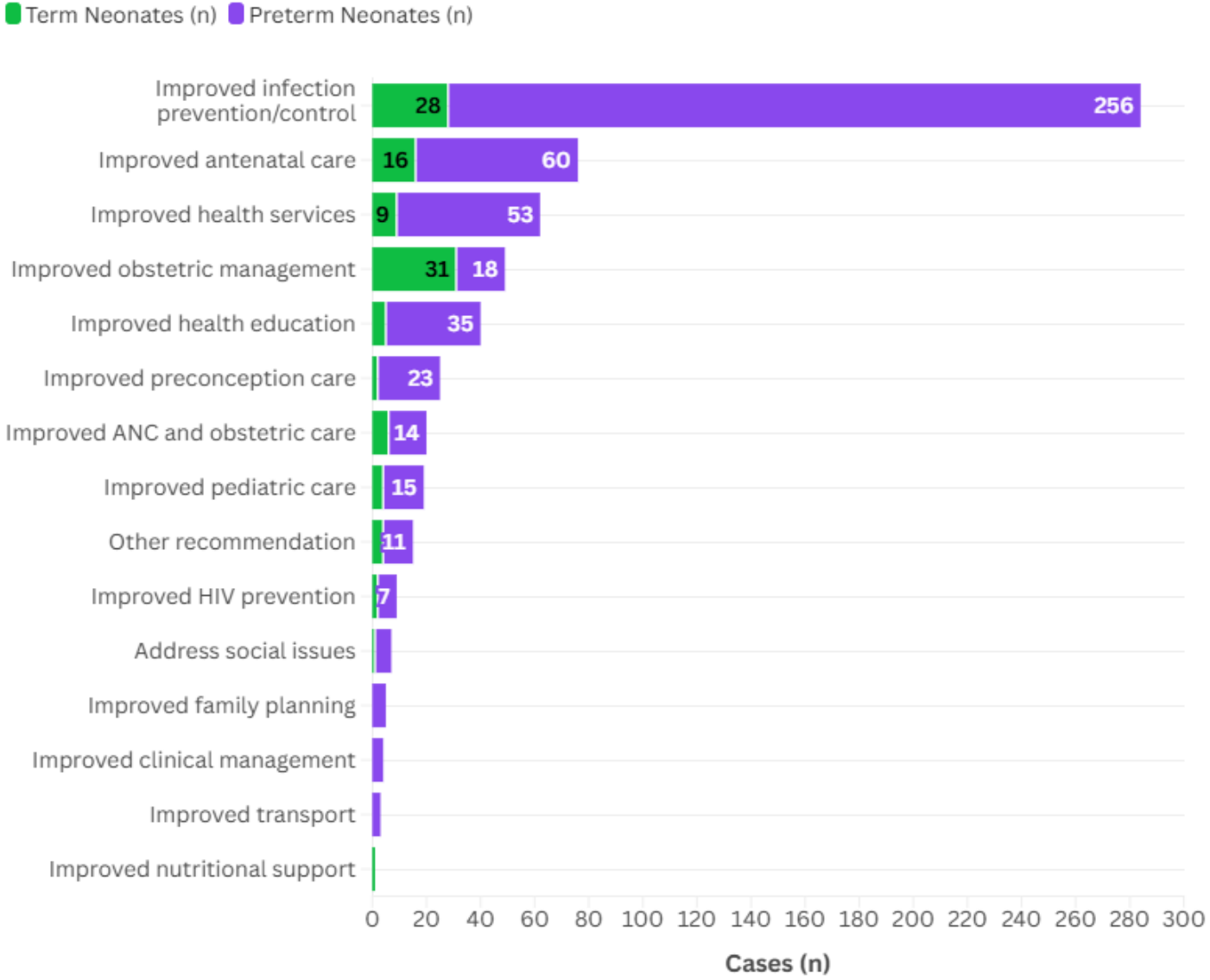
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Congenital infection	0 (0.0%)	25 (2.4%)	30 (2.4%)
Umbilical cord complications	1 (4.0%)	21 (2.0%)	55 (4.4%)
Undetermined	1 (4.0%)	21 (2.0%)	55 (4.4%)
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Meningitis/Encephalitis	1 (4.0%)	3 (0.3%)	6 (0.5%)
Chorioamnionitis and related	0 (0.0%)	5 (0.5%)	5 (0.4%)
Other infections	2 (8.0%)	1 (0.1%)	7 (0.6%)

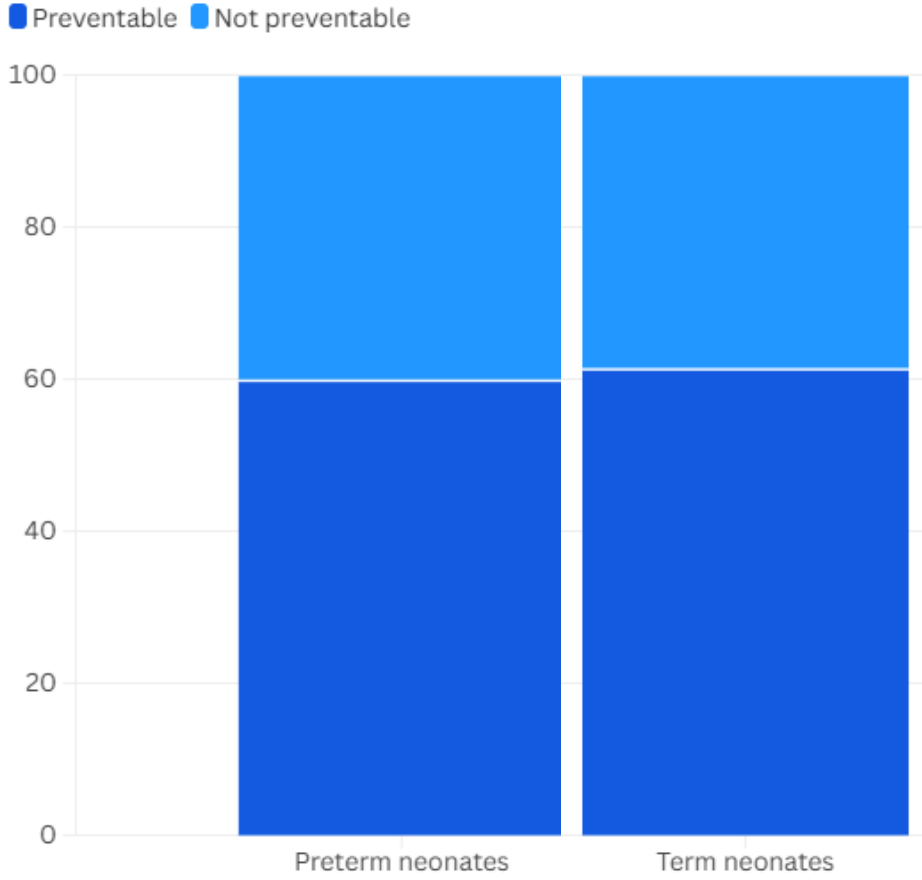
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Etiology

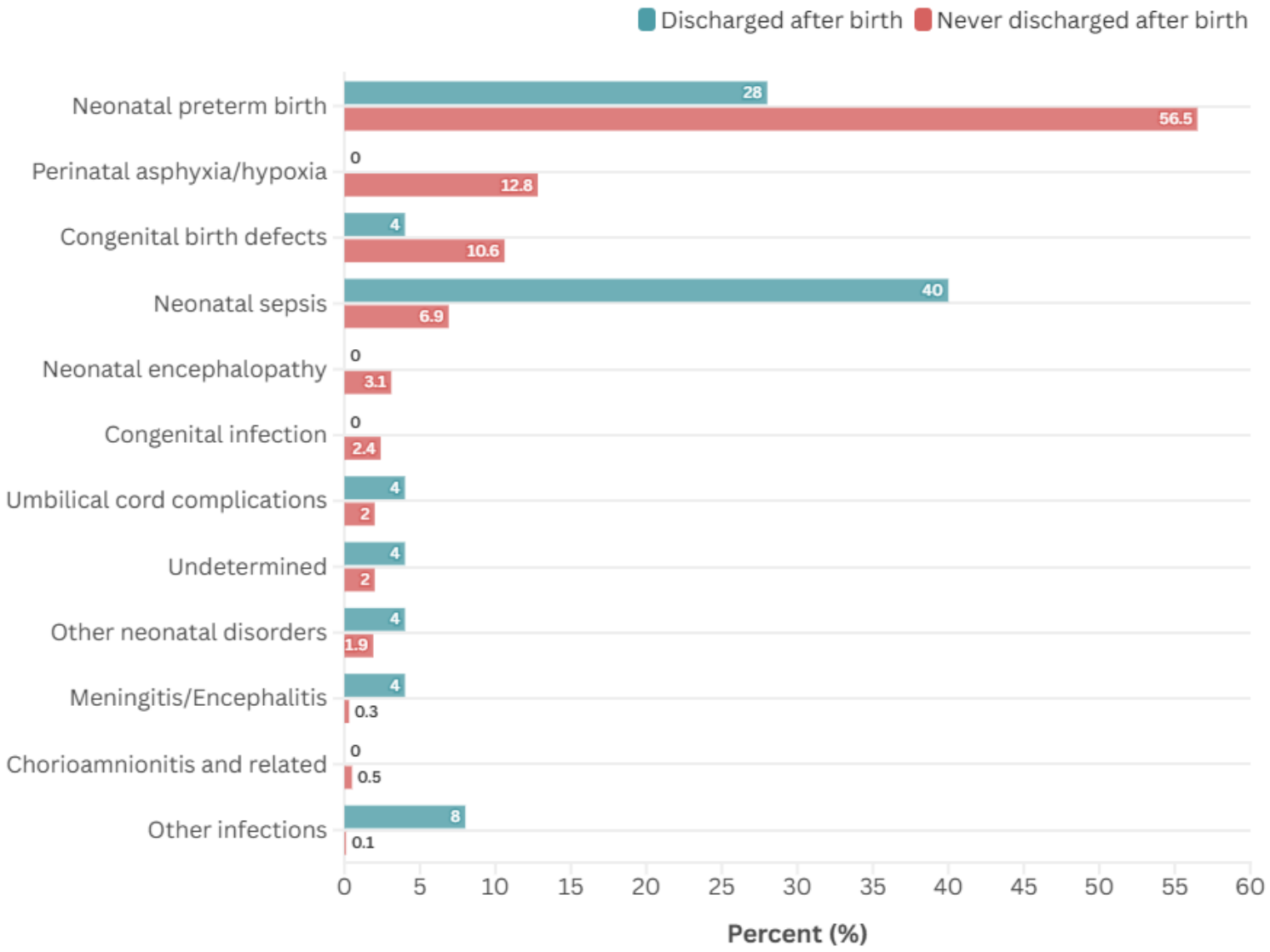
Etiology	Term (n; %)	Preterm (n; %)	Total (n; %)
Acinetobacter baumannii	30 (18.1%)	234 (34.9%)	264 (31.6%)
Klebsiella pneumoniae	22 (13.3%)	140 (20.9%)	162 (19.4%)
Streptococcus agalactiae	14 (8.4%)	32 (4.8%)	46 (5.5%)
Escherichia coli	9 (5.4%)	44 (6.6%)	53 (6.3%)
Enterococcus faecalis	6 (3.6%)	30 (4.5%)	36 (4.3%)
Staphylococcus aureus	6 (3.6%)	16 (2.4%)	22 (2.6%)
Enterococcus faecium	5 (3.0%)	33 (4.9%)	38 (4.5%)
Pseudomonas aeruginosa	2 (1.2%)	13 (1.9%)	15 (1.8%)
Ureaplasma spp	2 (1.2%)	4 (0.6%)	6 (0.7%)
Candida parapsilosis	1 (0.6%)	9 (1.3%)	10 (1.2%)
Cytomegalovirus (CMV)	1 (0.6%)	9 (1.3%)	10 (1.2%)
Enterobacter cloacae	1 (0.6%)	8 (1.2%)	9 (1.1%)
Enterococcus spp	1 (0.6%)	2 (0.3%)	3 (0.4%)
Listeria monocytogenes	1 (0.6%)	4 (0.6%)	5 (0.6%)
Serratia marcescens	1 (0.6%)	9 (1.3%)	10 (1.2%)
Streptococcus pneumoniae	1 (0.6%)	3 (0.4%)	4 (0.5%)
Streptococcus spp	1 (0.6%)	5 (0.7%)	6 (0.7%)
Treponema pallidum	1 (0.6%)	5 (0.7%)	6 (0.7%)
Candida albicans	–	20 (3.0%)	20 (2.4%)
Candida auris	–	8 (1.2%)	8 (1.0%)

Preventability





Difference in Underlying COD between those discharged/never discharged



Difference in Immediate COD between those discharged/never discharged

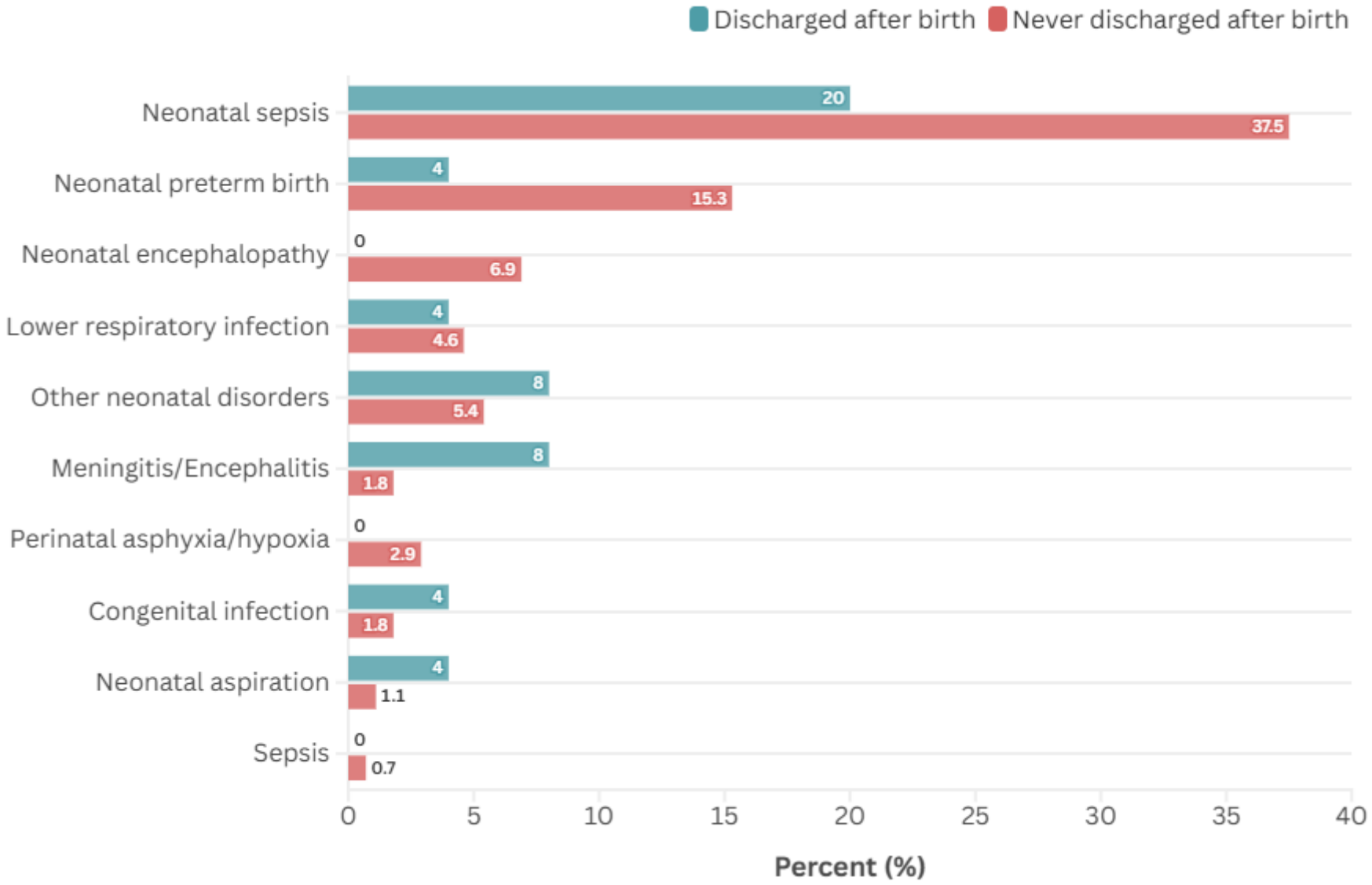
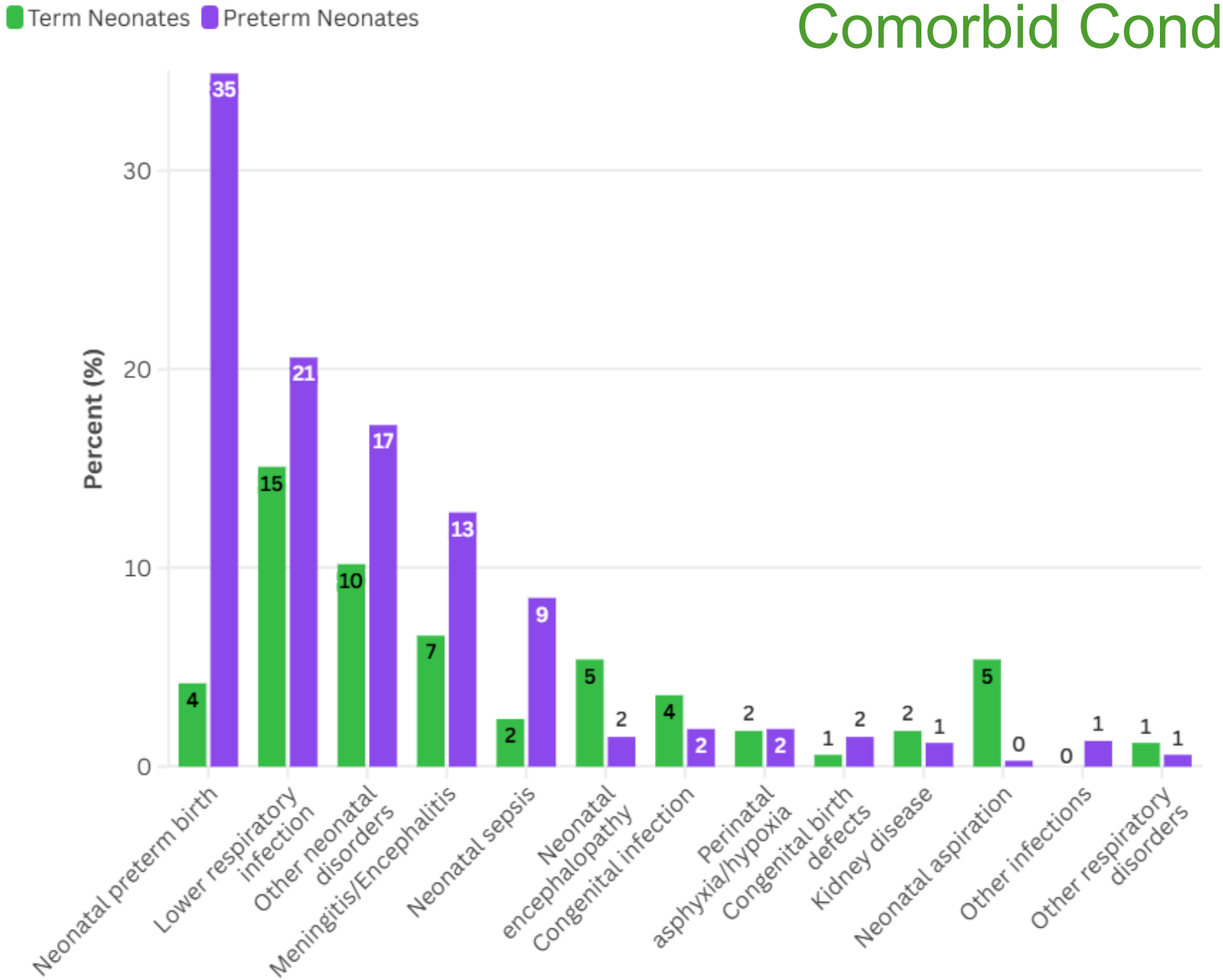


Table of characteristics

Characteristic	Category	Term (n=166)	Preterm (n=670)	Total (n=836)
Location of death	Community	2 (1,2%)	4 (0,6%)	6 (0,7%)
HIV*	Exposed	41 (24,7%)	240 (35,8%)	280 (33,6%)
Sex	Male	87 (52,4%)	395 (59,0%)	482 (57,7%)
Birthweight*	Low birthweight	20 (19,42%)	415 (97,4%)	435 (82,2%)
Birthweight category*	<1000g	0 (0,0%)	238 (55,9%)	238 (45,0%)
	1000-1499g	4 (3,9%)	115 (27,0%)	119 (22,5%)
	1500-1999g	4 (3,9%)	38 (8,9%)	42 (7,9%)
	2000-2499g	12 (11,7%)	24 (5,6%)	36 (6,8%)
	2500g	83 (80,6%)	11 (2,6%)	94 (17,8%)
Mode of delivery	C-section	71 (42,8%)	286 (42,7%)	357 (42,7%)
ANC booking	Unbooked	0 (0,0%)	16 (2,3%)	16 (1,9%)
Admission	Never discharged	152 (91,6%)	653 (97,5%)	805 (96,3%)

*indicates significant difference at p-value<0,05
Where data not available for all MITS cases percentages were calculated only among cases with known values

Comorbid Conditions



CHAMPS

Conclusion

- Most sampled neonatal deaths were preterm, with the majority born extremely preterm (<28 weeks).
- Prematurity-related complications were the predominant causes of death among preterm infants, while term infants had a broader range of infectious and congenital causes.
- HIV exposure was more common in the preterm group, consistent with emerging literature[1].
- Maternal hypertension was the leading maternal condition associated with neonatal deaths and was higher among deaths in preterm neonates.
- Key pathogens identified were *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Escherichia coli*.
- Priority modifiable factors included improved infection prevention and control (IPC), strengthened antenatal care, and earlier healthcare-seeking behaviour.

[1]Xiao, Peng-Lei, Yi-Biao Zhou, Yue Chen, Mei-Xia Yang, Xiu-Xia Song, Yan Shi, and Qing-Wu Jiang. 2015. "Association between Maternal HIV Infection and Low Birth Weight and Prematurity: A Meta-Analysis of Cohort Studies." *BMC Pregnancy and Childbirth* 15:246. doi:10.1186/s12884-015-0684-z.