

LITTLE ADULTS? EVOLVING TRENDS OF MORBIDITY AND MORTALITY IN THE PEDIATRIC POPULATION

Paulo B. Pinho, MD, DBIM, FAAP, FACP

Chief Medical and Strategy Officer, Meridian Analytics

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Meridian
ANALYTICS



AGENDA

- IT'S ALL ABOUT GROWTH
- TERMINOLOGY
- HISTORY OF PEDIATRICS
- *EX TOTO NON SIC PUERI UT VIRI CURARI DEBENT*
- PEDIATRIC MORTALITY DATA
- OVERALL GROWTH AND DEVELOPMENT
 - Embryogenesis and infant mortality
 - Growth
 - Development
- AND THEN THERE'S THE TESTS
- NORMAL WELL CARE - VACCINATION & SCREENING
- MALIGNANCY KEPT SHOWING UP, SO . . .
- CONCLUSIONS/QUESTIONS

It's all about Growth

The child's personality is a product of slow gradual growth. His nervous system matures by stages and natural sequences. He sits before he stands; he babbles before he talks; he fabricates before he tells the truth; he draws a circle before he draws a square; he is selfish before he is altruistic; he is dependent on others before he achieves dependence on self. All of his abilities, including his morals, are subject to laws of growth. The task of child care is not to force him into a predetermined pattern but to guide his growth. – [Arnold Gesell](#)



- **Pediatrics**

- from Greek *paido-*, combining form of *paid-* (stem of *paîs*) “child”
- From Greek *Iatros* – “healer”

- **Pediatrician**

- Medical doctors with specialized training in evaluating, diagnosing and treating children
- Major areas of impact

- Nutrition
- Growth
- Development
- Immunization
- Illness

Disease Prevention

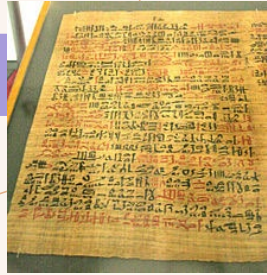
- **Pediatric Sub and Superspecialties – Transitional Specialties**

History of Pediatrics

1500's BC

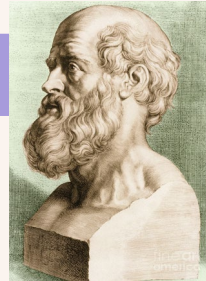
900's AD

**Ebers Papyrus
(1552 BC)**



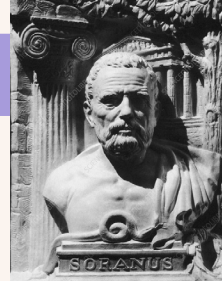
Breastfeeding,
cure for worms
and treatment
of ocular
diseases

**Hippocrates
(400 BC)**



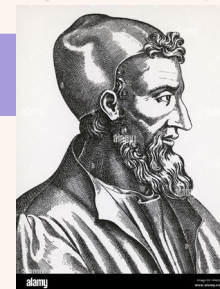
Asthma,
Cephalohema-
oma, Clubfoot,
Hydrocephalus,
Mumps,
Scrofula,
Worms,
Epilepsy,
Prematurity

**Soranus of Ephesus
(100 AD)**



Checking
nutrition
based on
physical
exam, fat
content of
breast milk

**Galen
(200 AD)**



Ear
discharge,
pneumonia,
intestinal
prolapse

**Avicenna
(990 AD)**

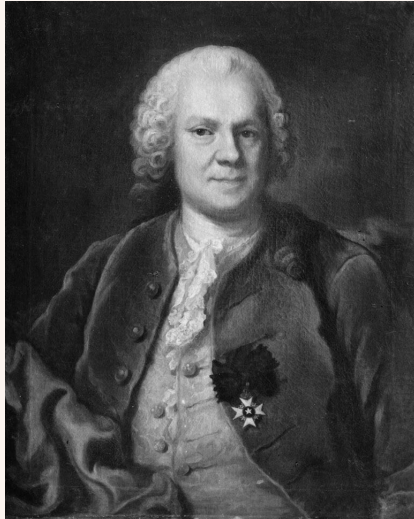


Convulsions,
Meningitis,
Tetanus,
Umbilical
Abscess,
Worms



History of Pediatrics

Nils Rosén von Rosenstein 1706-1773



- Swedish physician
- Founder of Modern Pediatrics
- Book titled “The Disease of Children and their Remedies” is considered to be the first textbook of pediatrics

Hôpital des Enfants Malades (Opened in Paris in 1802)



- Generally accepted as the first pediatric hospital
- Presently called Hôpital Necker-Enfants maladies after a 1920 merger with Necker hospital

Ex toto non sic pueri ut viri curari debent

- **“In general, boys should not be treated in the same way as men.”**

– works of Hippocrates, Aristotle, Celsius, Soranus and Galen

- **General Medicine \neq Pediatric Medicine**

- **Unique Biology**

- More Congenital/Inherited, Nutritional, Infectious
 - Less Degenerative and Psychiatric

- **Distinct Risk Factors**

- **Unique Clinical Manifestations**

- **Body Proportional Differences**

- **Metabolic differences**

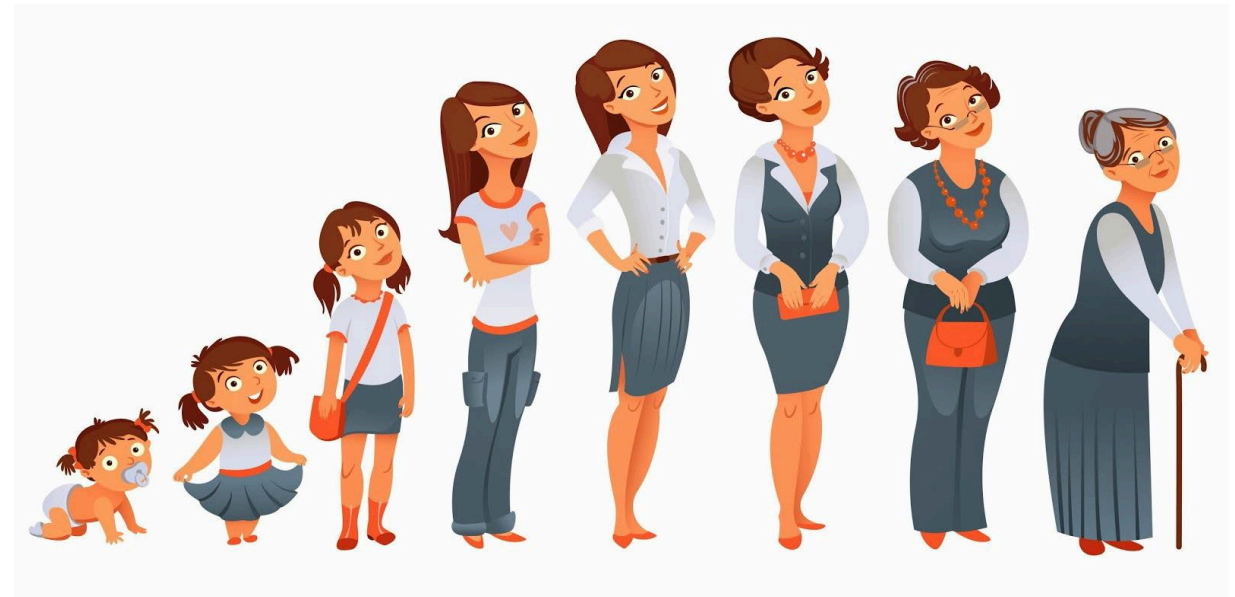
- Drug dosing per unit weight
 - Fluid intake
 - Vital signs
 - Greater Volume of Distribution

- **Response to disease and treatment is varied**

- Rapid decline
 - Rapid improvement

- **Growing / developing individuals**

- Diseases of children affect Growth and Development \rightarrow Growth and Development disorders as a symptom



PEDIATRIC MORTALITY DATA

- GENERAL
- OVER TIME
- BY CAUSE
- BY AGE
- GLOBALLY

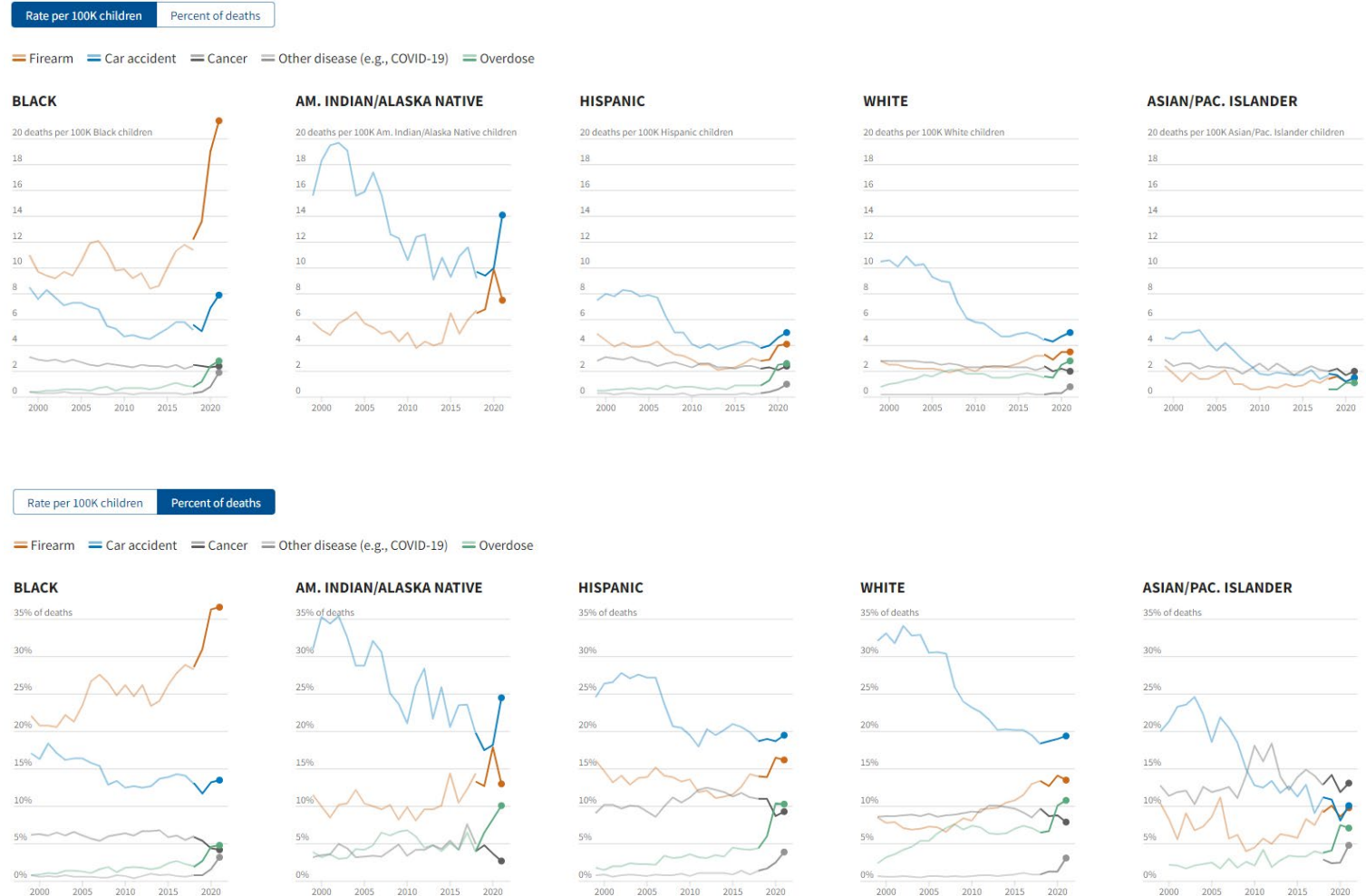
2016 Pediatric Mortality Statistics

- **Age 1-19 represent ¼ of the US population – thankfully only 2% of deaths – rare event**
- **Reduction in infectious disease and cancer death due to diagnosis, vaccinations, antibiotics, medical-surgical treatment**
- **Increase in injury – MV crashes, firearms, opioids (preventable)**
 - 2016 – 20,360 – injuries were 60% and 6 of the top 10 causes
- **In 1900 – leading causes of death for the population were TB, pneumonia, diarrhea**
 - 2016 – these didn't make the list
 - Malignant neoplasms decreased 32% from 1990->2016 – prevention, detection and treatment
- **Social factors –**
 - Rural children and adolescents higher mortality – higher injuries, further from access, higher speeds and less divided roads
 - Homicide higher in urban, overdose higher in urban

Pediatric Mortality Statistics (2016 & 2023)

Demographics

- M > F (1.2x at 1 year, 2.8 at 19 years)
- n/100K –
 - Blacks (38.2) – both injury and non-injury (heart and respiratory)
 - American Indians/Alaskan Natives (28),
 - Whites (24.2)
 - Asians/Pacific Islanders (15.9)
 - Whites – highest in drug overdose
- Non-Hispanics > Hispanics – although underestimation may be happening



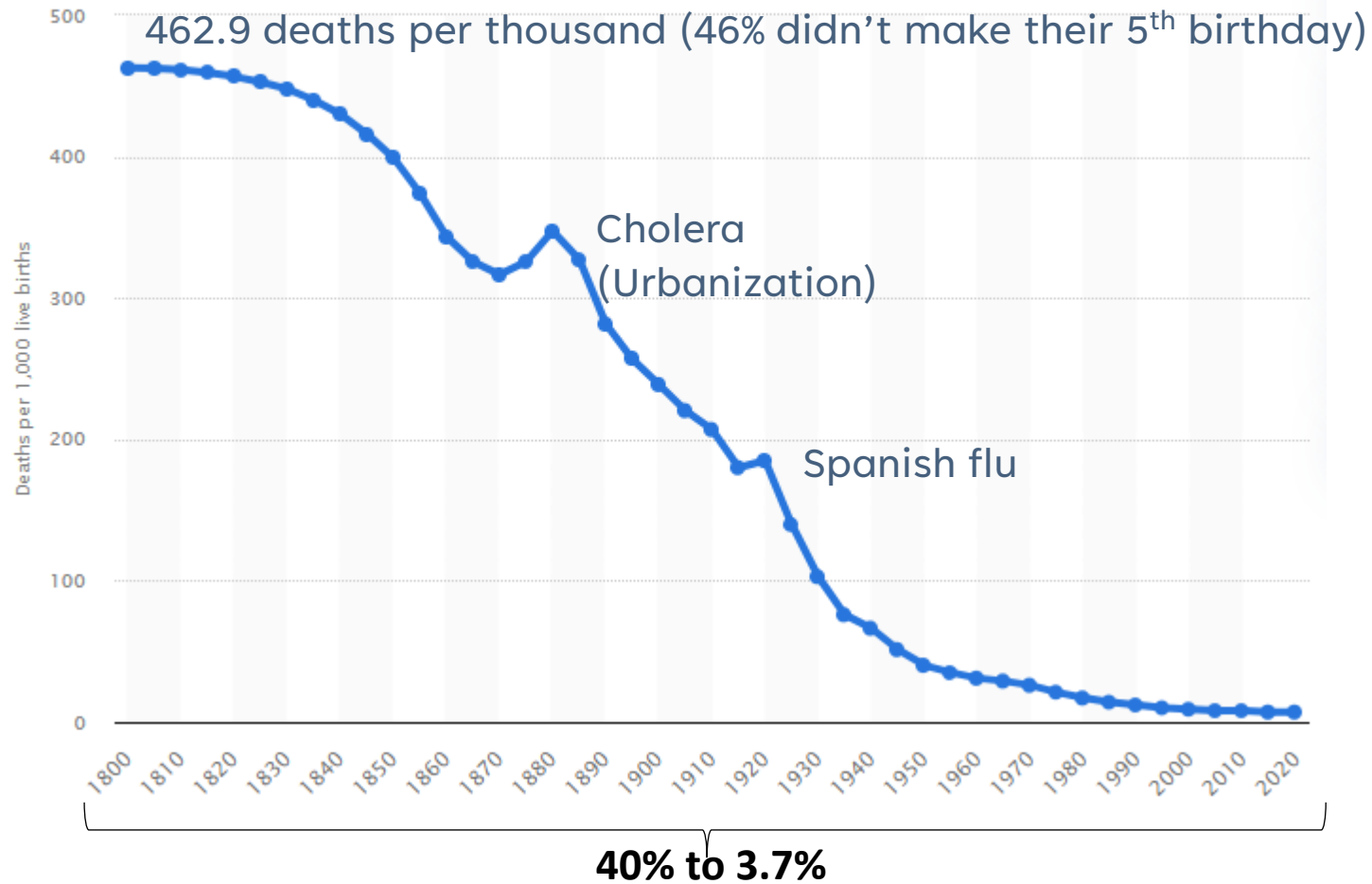
[Children are dying at the highest rate in 13 years \(usafacts.org\)](https://www.usafacts.org)

The Major Causes of Death in Children and Adolescents in the United States

December 20, 2018
 N Engl J Med 2018; 379:2468-2475
 DOI: 10.1056/NEJMs1804754

Rebecca M. Cunningham, M.D., Maureen A. Walton, M.P.H., Ph.D., and Patrick M. Carter, M.D.

Pediatric Mortality Statistics – 1800-2020



[United States: child mortality rate 1800-2020 | Statista](#)

[What was the infant mortality rate in the 1800s? – AnswersAll \(answer-all.com\)](#)

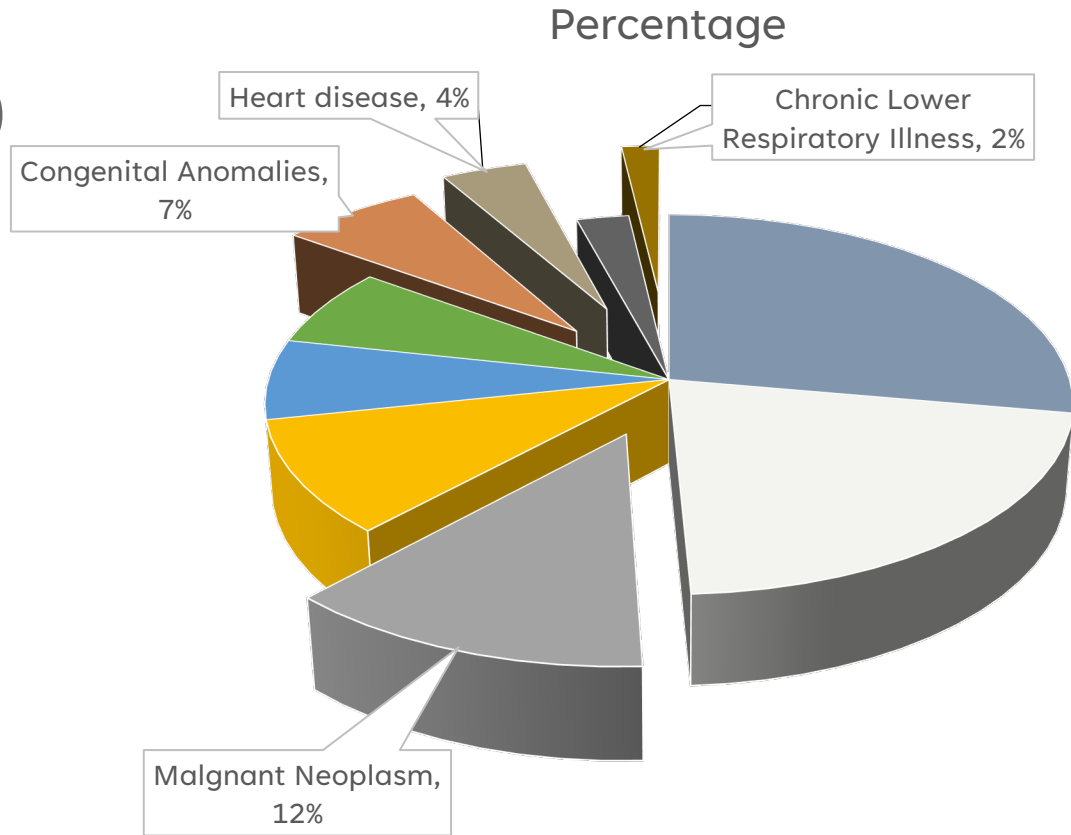
[How child mortality fell from 40% to 3.7% in 200 years - Big Think](#)

2016 Pediatric Mortality Statistics (Top 10 = 71.90%)

Table 1. The 10 Leading Causes of Child and Adolescent Death in the United States in 2016, in Order of Frequency.*

Cause of Death	No. of Deaths	Rate per 100,000 (95% CI)	Percent of Deaths
All causes	20,360	26.06 (25.70–26.42)	
All injury-related causes	12,336	15.79 (15.51–16.07)	60.6
Motor vehicle crash	4,074	5.21 (5.06–5.38)	20.0
Firearm-related injury	3,143	4.02 (3.88–4.16)	15.4
Homicide	1,865	2.39 (2.28–2.50)	
Suicide	1,102	1.41 (1.33–1.50)	
Unintentional	126	0.16 (0.13–0.19)	
Undetermined intent	50	0.06 (0.05–0.09)	
Malignant neoplasm	1,853	2.37 (2.27–2.48)	9.1
Suffocation†	1,430	1.83 (1.74–1.93)	7.0
Suicide	1,110	1.42 (1.34–1.51)	
Unintentional	235	0.30 (0.26–0.34)	
Drowning	995	1.27 (1.20–1.36)	4.9
Drug overdose or poisoning	982	1.26 (1.18–1.34)	4.8
Suicide	123	0.16 (0.13–0.19)	
Unintentional	761	0.97 (0.91–1.05)	
Congenital anomalies	979	1.25 (1.18–1.33)	4.8
Heart disease	599	0.77 (0.71–0.83)	2.9
Fire or burns	340	0.44 (0.39–0.48)	1.7
Unintentional	272	0.35 (0.31–0.39)	
Chronic lower respiratory disease	274	0.35 (0.31–0.40)	1.3

84.2% of Top 10

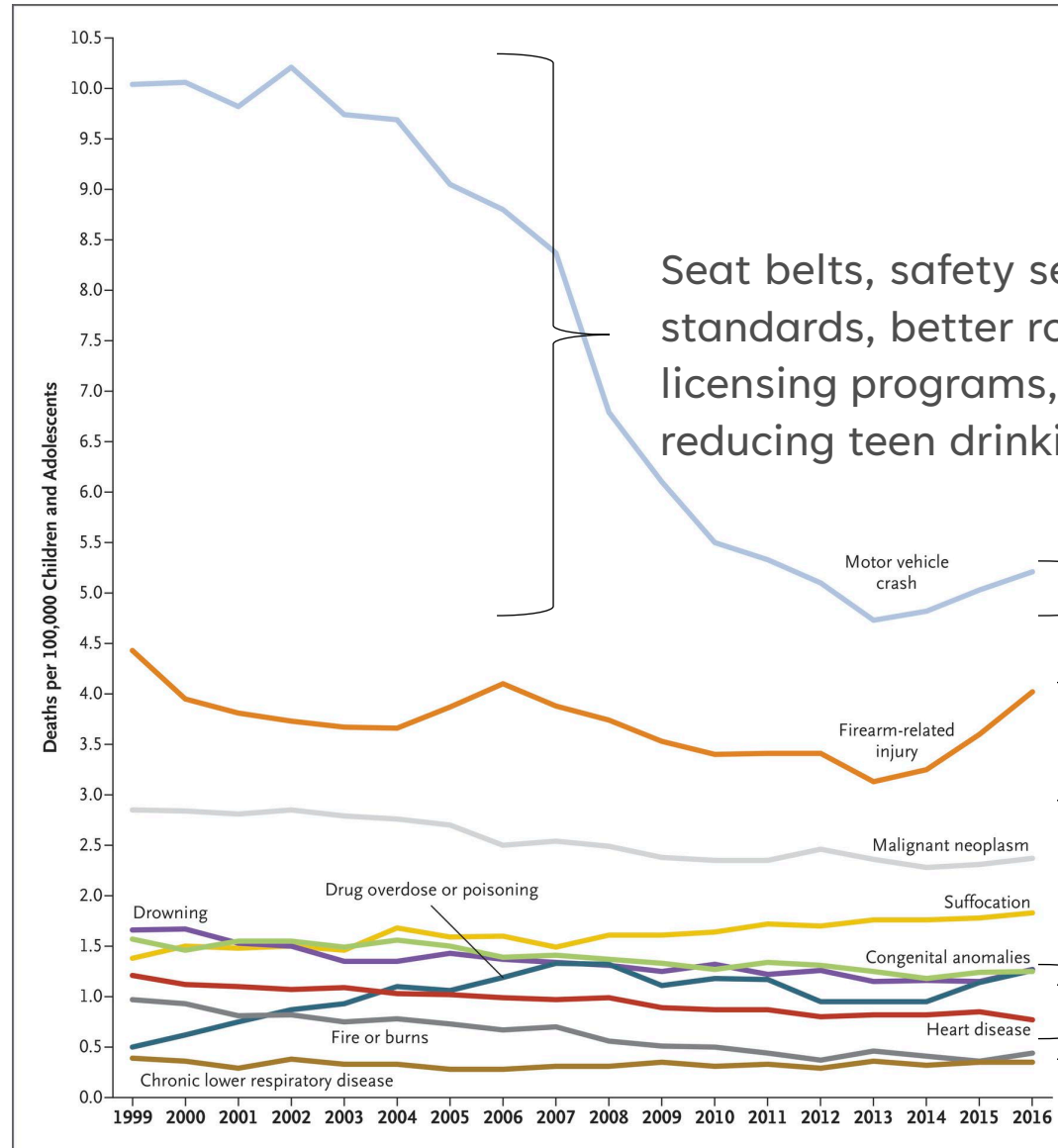
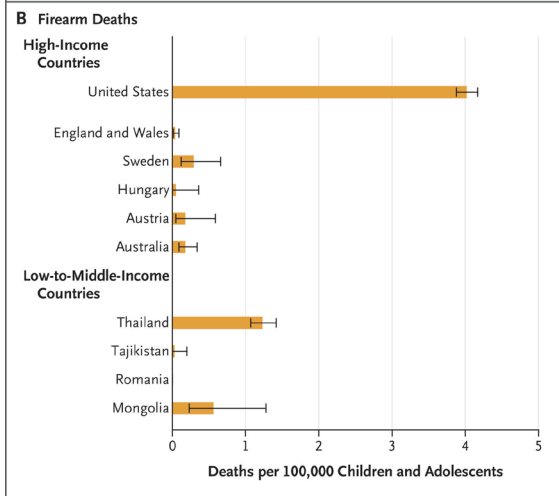
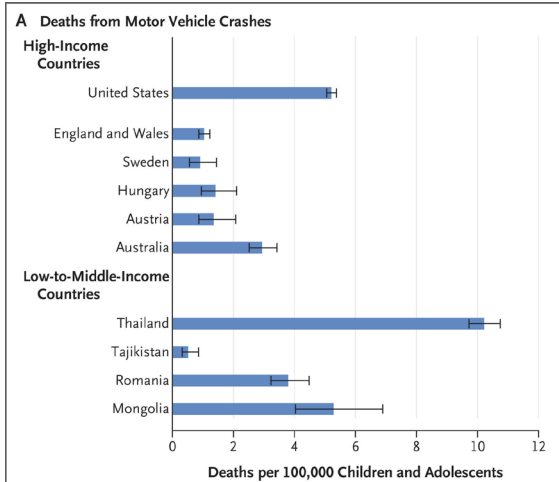


* Data were obtained from the Wide-ranging Online Data for Epidemiologic Research system of the Centers for Disease Control and Prevention,² according to the codes of the *International Classification of Diseases, 10th Revision (ICD-10)*,³ for the leading causes of death among children and adolescents. Age was restricted to children and adolescents 1 to 19 years of age. Crude rates (deaths per 100,000) were calculated with a population denominator of 78,134,923, with 95% confidence intervals (CIs) presented. All data are calculated for 2016, the most recent year with available data. See Table S1 in the Supplementary Appendix for more data regarding intent (homicide, suicide, unintentional, or undetermined).

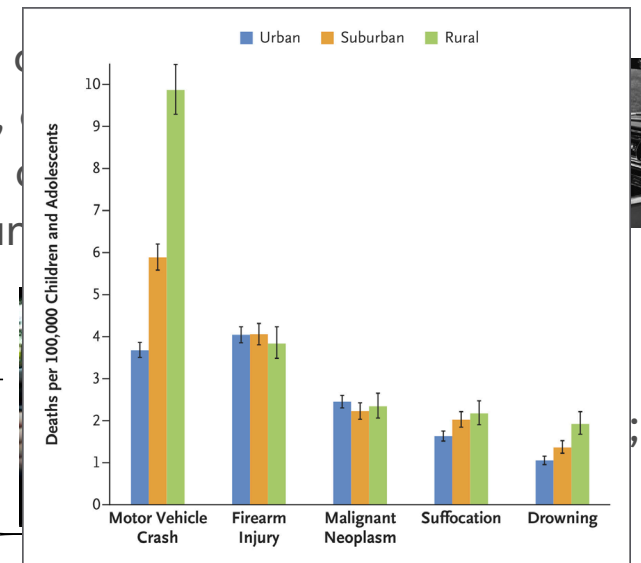
† Suffocation includes such incidents as suffocation or strangulation due to bed linen, the mother's body, pillows, or plastic bags. It also includes aspiration or obstruction of the airway by a food bolus, a foreign body, or vomitus. The category also includes intentional self-harm by hanging and intentional violence by strangulation or suffocation. For a complete list of ICD codes and definitions, see Figure S3 in the Supplementary Appendix.

- Motor Vehicle
- Firearm
- Malignant Neoplasm
- Suffocation
- Drowning
- Drug Overdose/Poisoning
- Congenital Anomalies
- Heart disease
- Fire/Burns
- Chronic Lower Respiratory Illness

2016 Pediatric Mortality Statistics



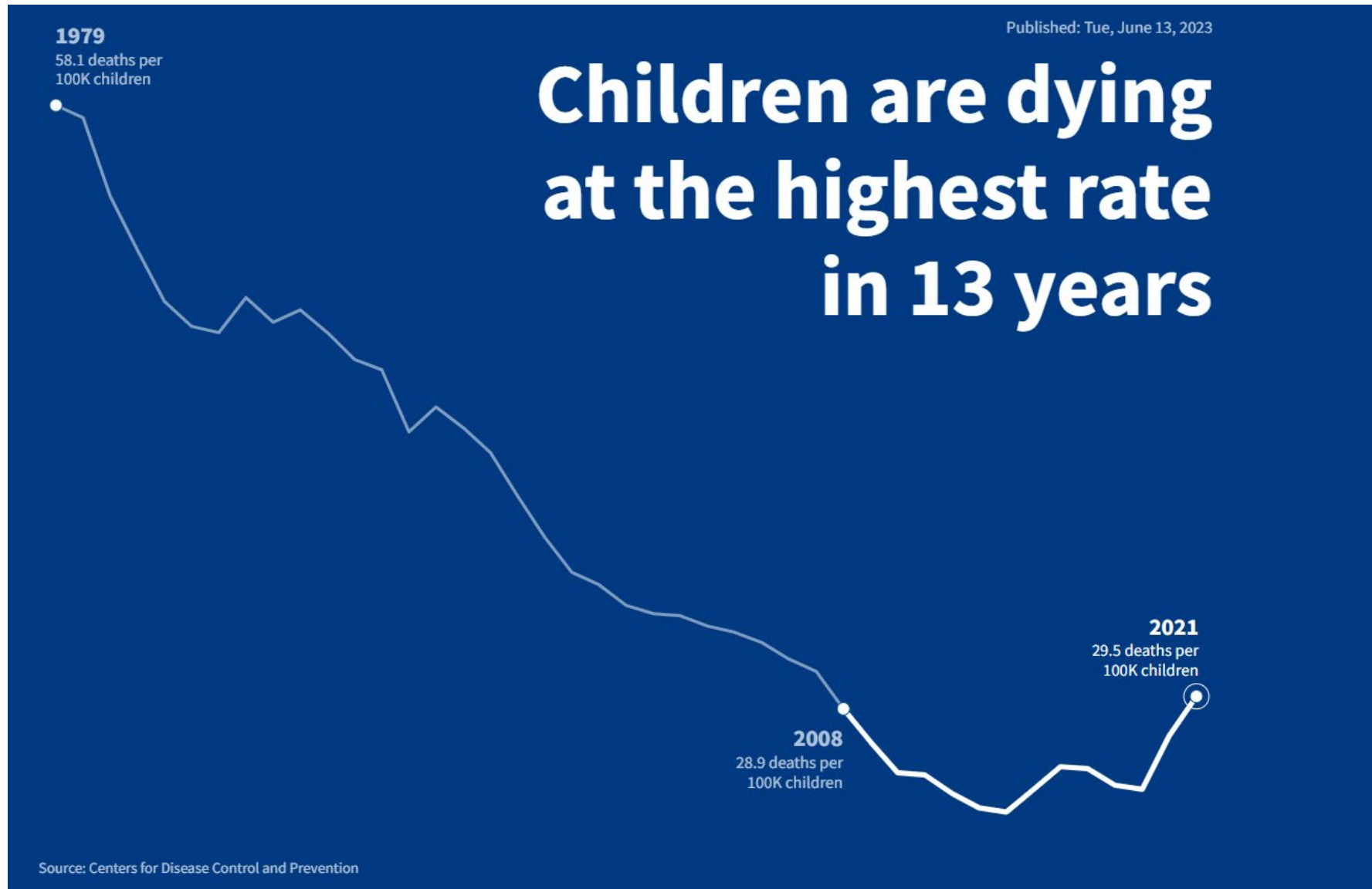
Seat belts, safety seats, car seat standards, better roads, licensing programs, and reducing teen drinking and driving



has a gun – 43% unlocked and loaded)

73% in burns and fires – Opioid crisis, smoke detectors, fire codes

2023 Pediatric Mortality Statistics

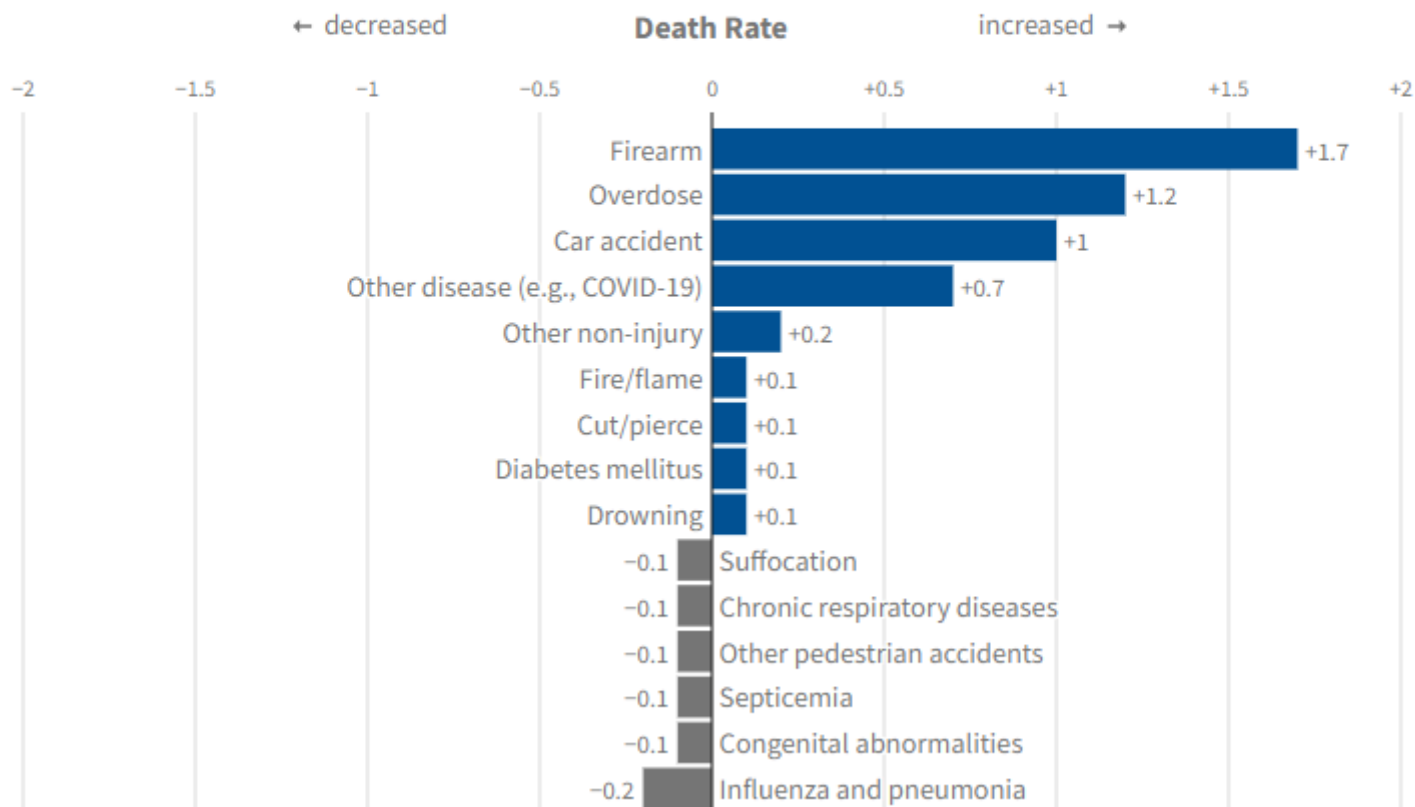


[Children are dying at the highest rate in 13 years \(usafacts.org\)](https://usafacts.org)

2023 Pediatric Mortality Statistics

Gun deaths, overdoses, and car accidents caused childhood deaths to rise during the pandemic.

Change in death rate by cause of death per 100K children, ages 1 through 19, between 2019 and 2021



[Children are dying at the highest rate in 13 years \(usafacts.org\)](https://usafacts.org)

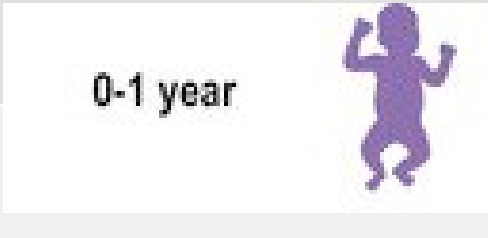




2017 Pediatric Mortality by Age

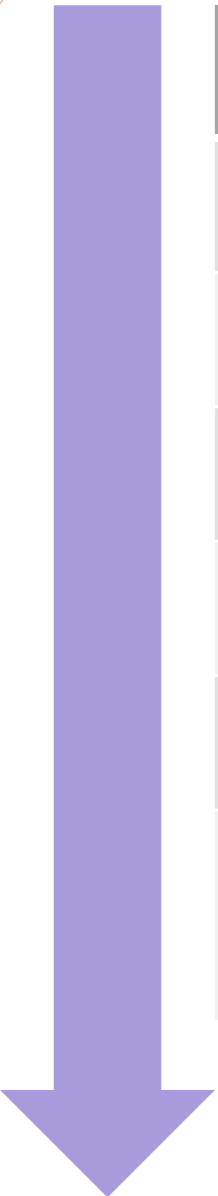


	<1		1-4		5-9		10-14		15-24		
1	Congenital Anomalies 4,580	30.2%	Unintentional Injury 1,267	46.1%	Unintentional Injury 718	40.4%	Unintentional Injury 860	34.4%	Unintentional Injury 13,441	47.9%	
2	Short Gestation 3,749	24.8%	Congenital Anomalies 424	15.4%	Malignant Neoplasms 418	23.5%	Suicide 517	20.7%	Suicide 6,252	22.3%	←
3	Maternal Pregnancy Complications 1,432	9.5%	Malignant Neoplasms 325	11.8%	Congenital Anomalies 188	10.6%	Malignant Neoplasms 437	17.5%	Homicide 4,905	17.5%	←
4	SIDS 1,363	9.0%	Homicide 303	11.0%	Homicide 154	8.7%	Congenital Anomalies 191	7.6%	Malignant Neoplasms 1,374	4.9%	←
5	Unintentional Injury 1,317	8.7%	Heart Disease 127	4.6%	Heart Disease 75	4.2%	Homicide 178	7.1%	Heart Disease 913	3.3%	←
6	Placental, Cord, Membranes 843	5.6%	Influenza & Pneumonia 104	3.8%	Influenza & Pneumonia 62	3.5%	Heart Disease 104	4.2%	Congenital Anomalies 355	1.3%	
7	Bacterial Sepsis 449	3.9%	Cerebrovascular 66	2.4%	Chronic Low Respiratory 59	3.3%	Chronic Low Respiratory 75	3.0%	Diabetes Mellitus 248	0.9%	
8	Circulatory System Disease 449	3.0%	Septicemia 48	1.7%	Cerebrovascular 41	2.3%	Cerebrovascular 56	2.2%	Influenza & Pneumonia 190	0.7%	←
9	Respiratory Distress 480	2.9%	Benign Neoplasm 44	1.6%	Septicemia 33	1.9%	Influenza & Pneumonia 51	2.0%	Chronic Low Respiratory 59	0.7%	←
10	Neonatal Hemorrhage 379	2.5%	Perinatal Period 42	1.5%	Benign Neoplasm 44	1.7%	Benign Neoplasm 31	1.2%	Complicated Pregnancy	0.6%	
	15,144	30.2%	2,750	5.5%	1,779	3.5%	2,500	5.0%	28,034	55.8%	50,207

OVERALL GROWTH AND DEVELOPMENT

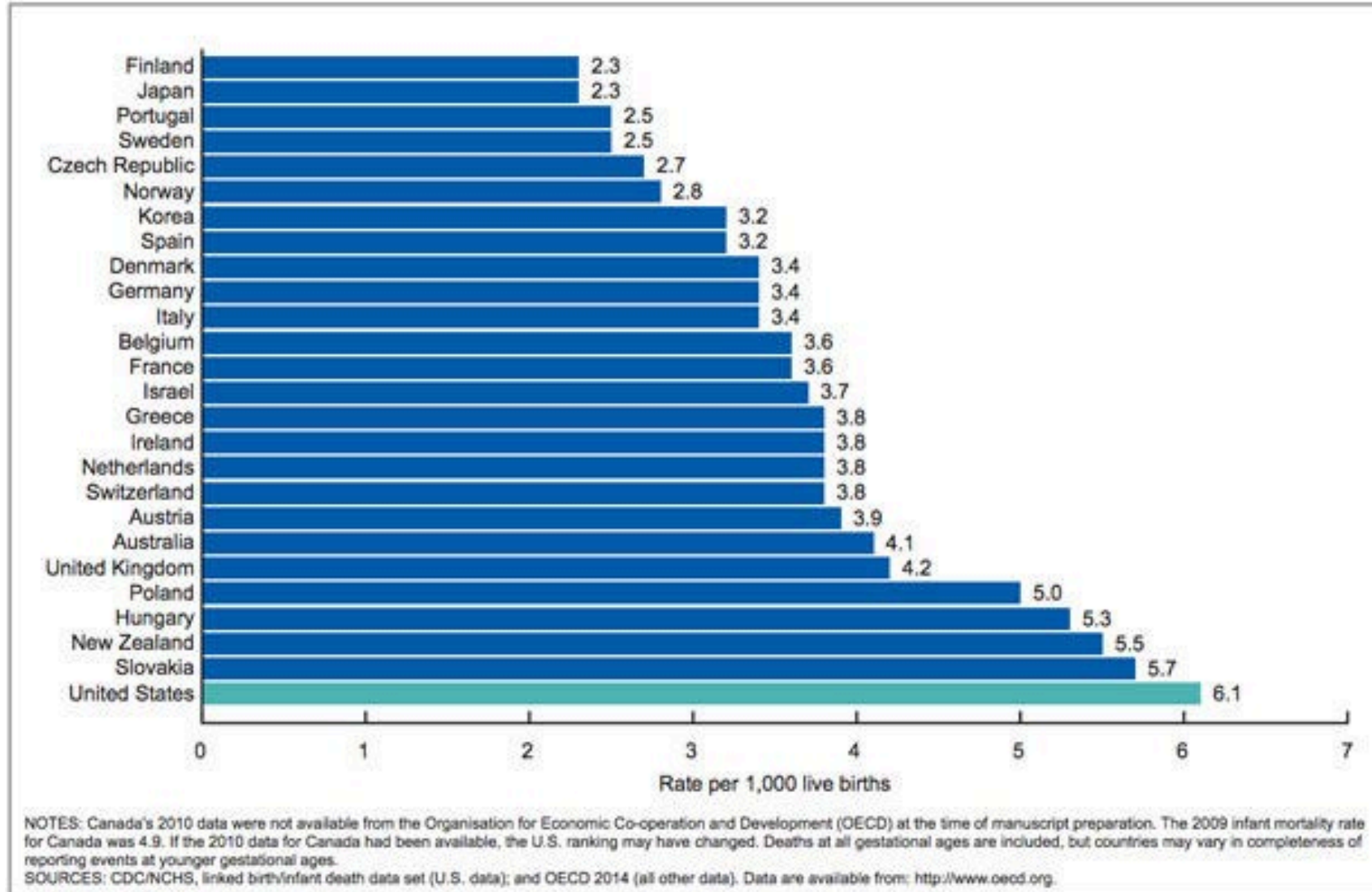
Periods of Growth and Development

Stages of Development	General Age Continuum	Hallmarks	Healthcare Goals
Neonatal (0-4 weeks)		Total dependence Poor regulation High Morbidity and Mortality	Nutrition Nursing Disease Prevention
Infancy (4 weeks-1 year)		Rapid growth Rapid motor and brain development Attachment, nutritional and Immunity needs	Nutrition Disease Prevention Basic Immunity
Toddler (1-3 years)		Growth slows Energy and exploration, risk taking Cognition	Nutrition Disease Prevention Accident Prevention
Preschool (3-6 years)		Maturity, morality and intelligence Mimicking adults Character forming – identity	Nutrition Disease & Accident Prevention Good Habits
School Age (6-12 years)		Steady Growth Decreased Incidence of disease Less Egocentricity – formed sense of self	Nutrition Vision, dental Psychological
Adolescence (12-18 years) – can be divided into Early, Middle, Late		Second fastest period of growth (11-13 in females, 13-17 in males) Neuroendocrine regulation Psychology, emotions, behavior Peers critical , autonomy commonplace	Nutrition Development Education Psychology

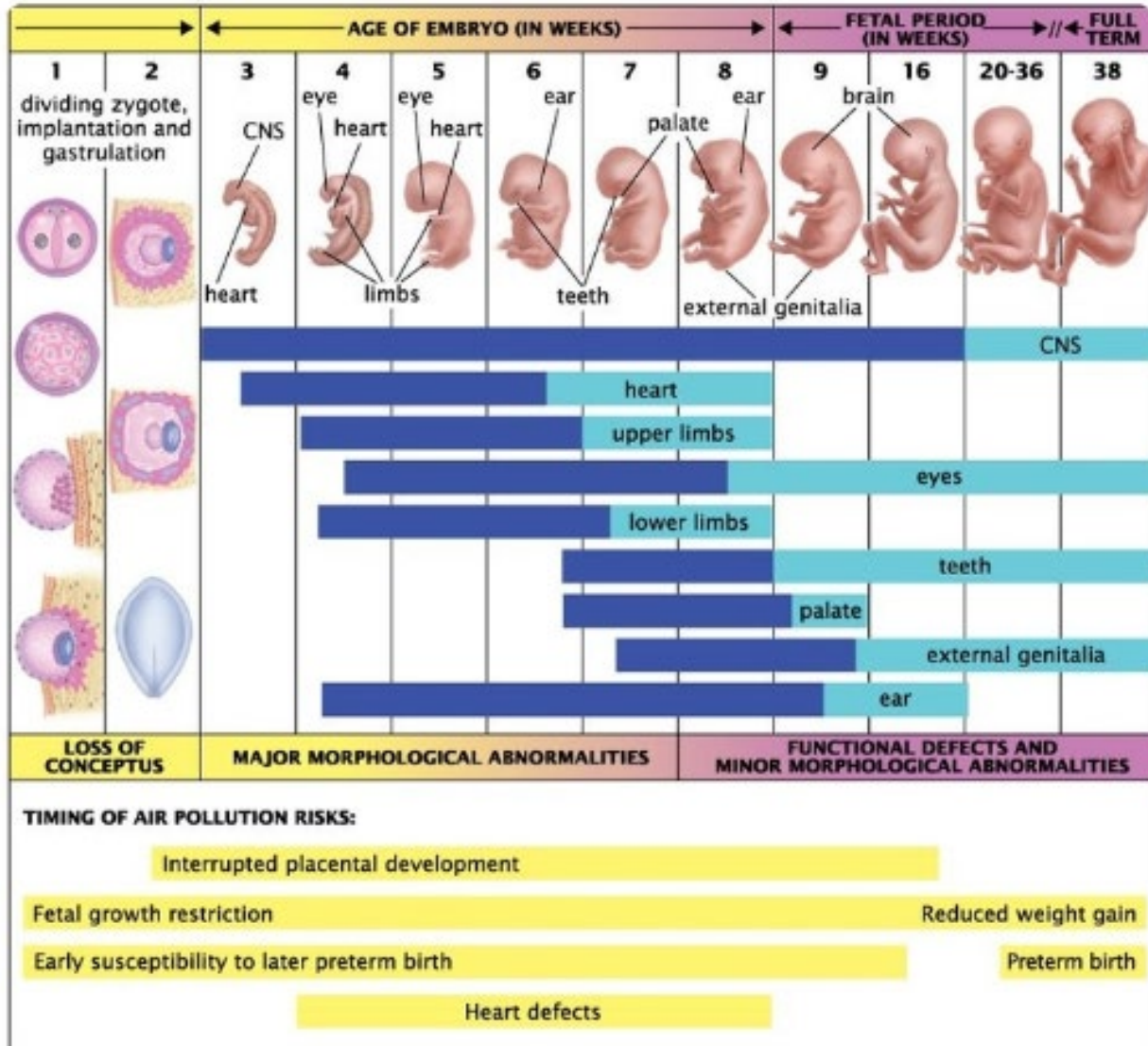


EMBRYOGENESIS AND INFANT MORTALITY

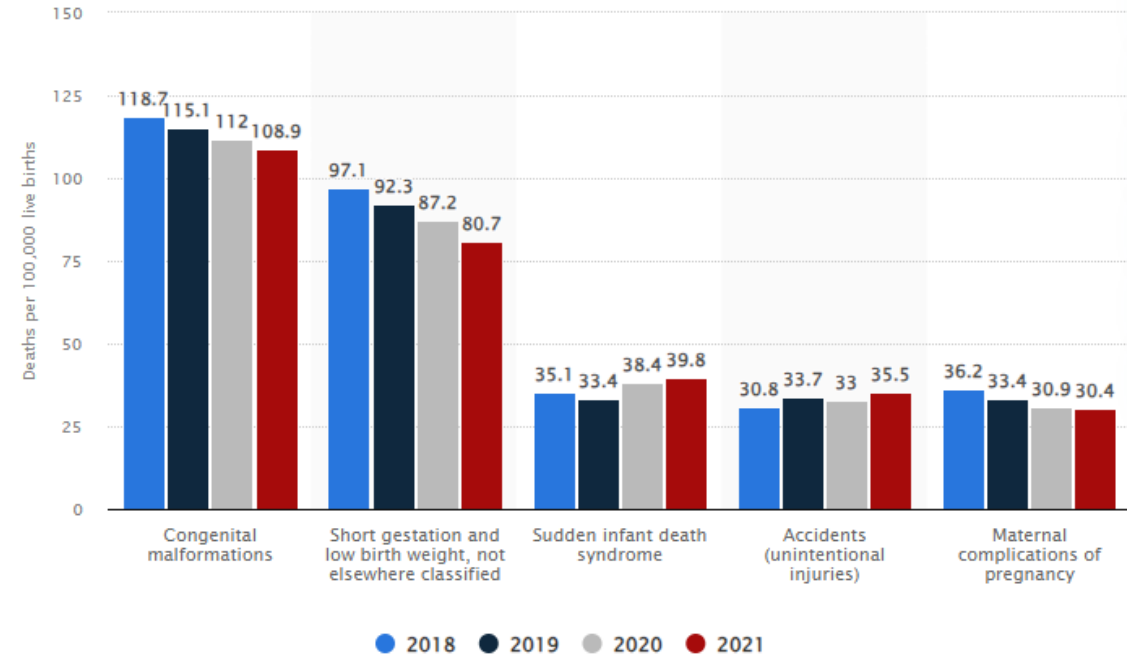
Infant Mortality



Embryogenesis and Infant Mortality

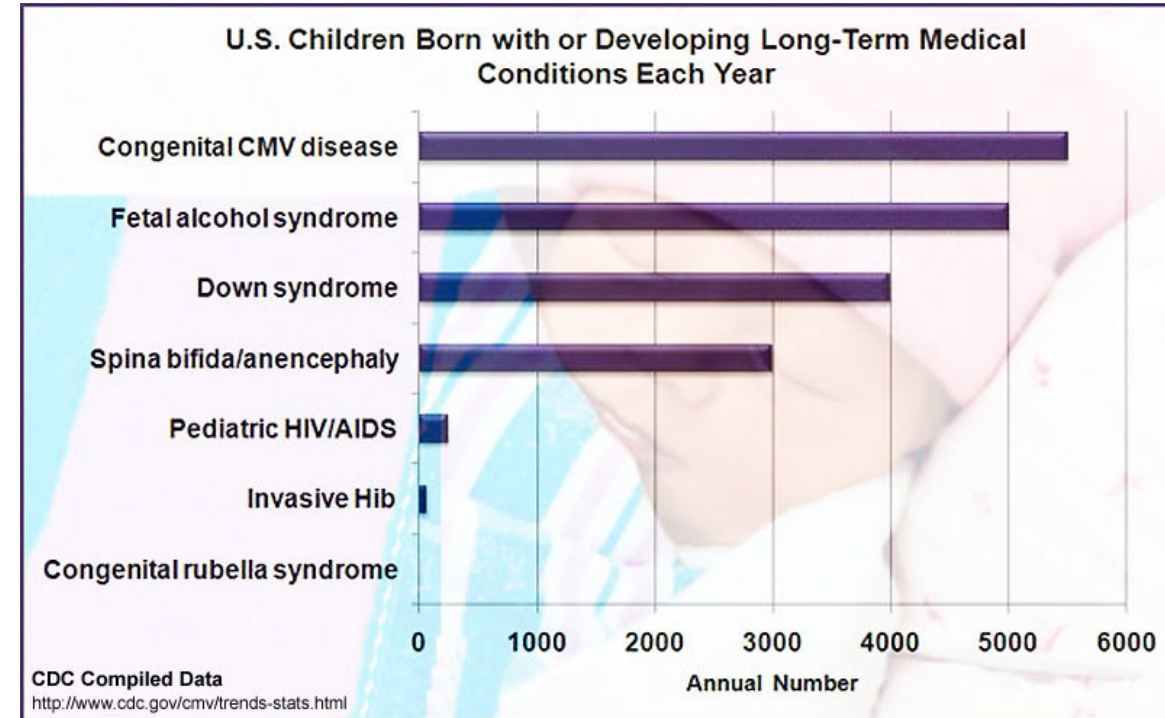
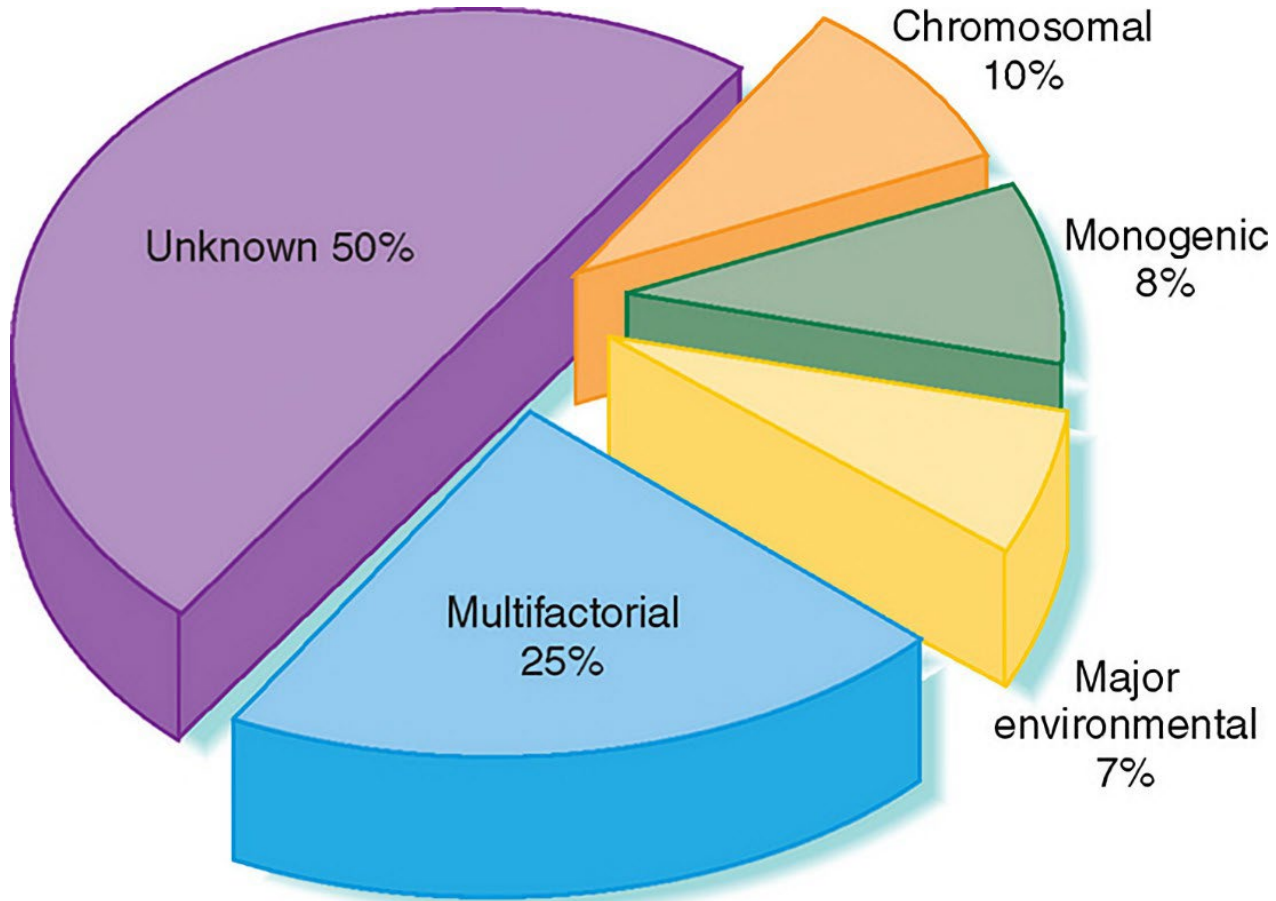


Note: Blue bars indicate time periods when major morphological abnormalities can occur, while light blue bars correspond to periods at risk for minor abnormalities and functional defects.



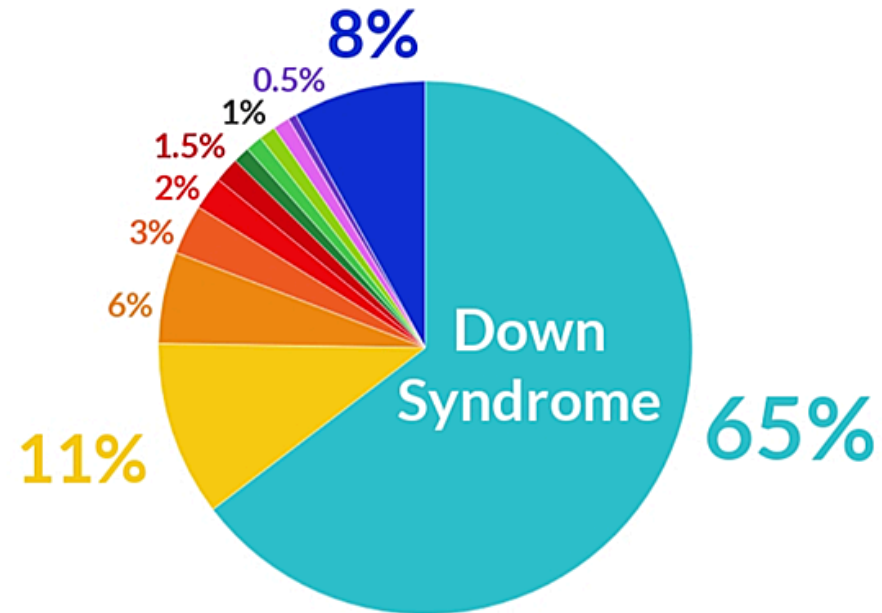
[Pinterest.](#)

Birth Anomalies can Happen for Many Reasons



[File: CDC Congenital abnormality graph.jpg - Embryology \(unsw.edu.au\)](#)

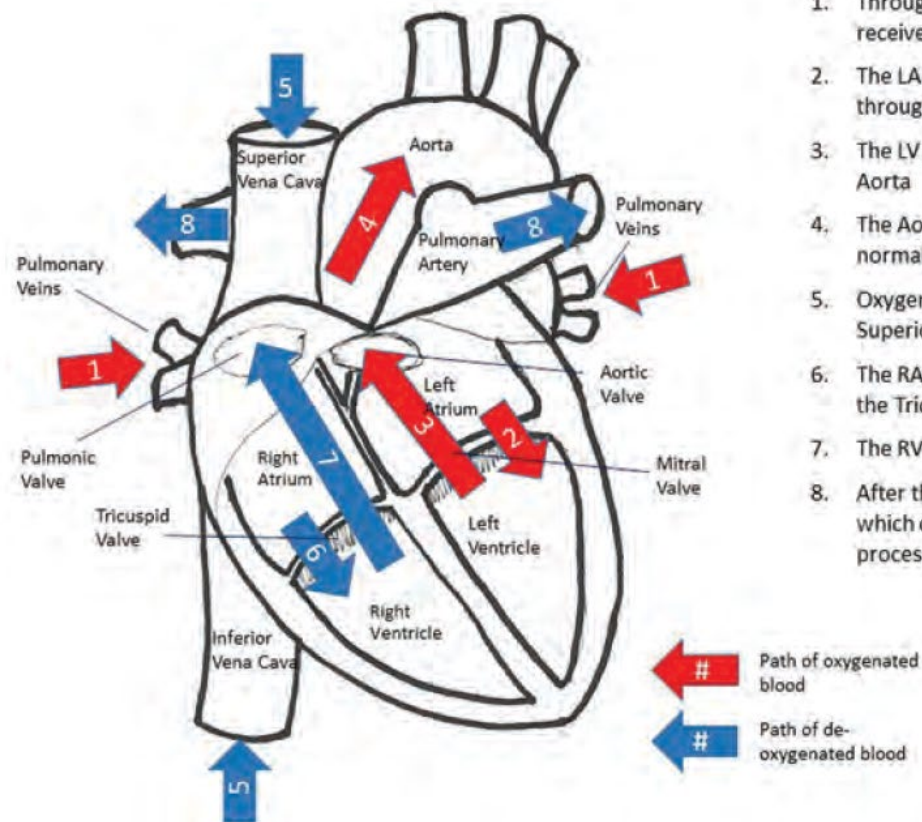
Chromosomal Abnormalities



Down syndrome	128	DiGeorge syndrome	21
Turner syndrome	11	Williams syndrome	6
Noonan syndrome	4	Edwards syndrome	3
Joubert syndrome	2	Rubinstein Taybi syndrome	2
CHARGE syndrome	2	Patau syndrome	2
Prader Willi syndrome	1	Others	16

Normal Newborn/Adult Circulation

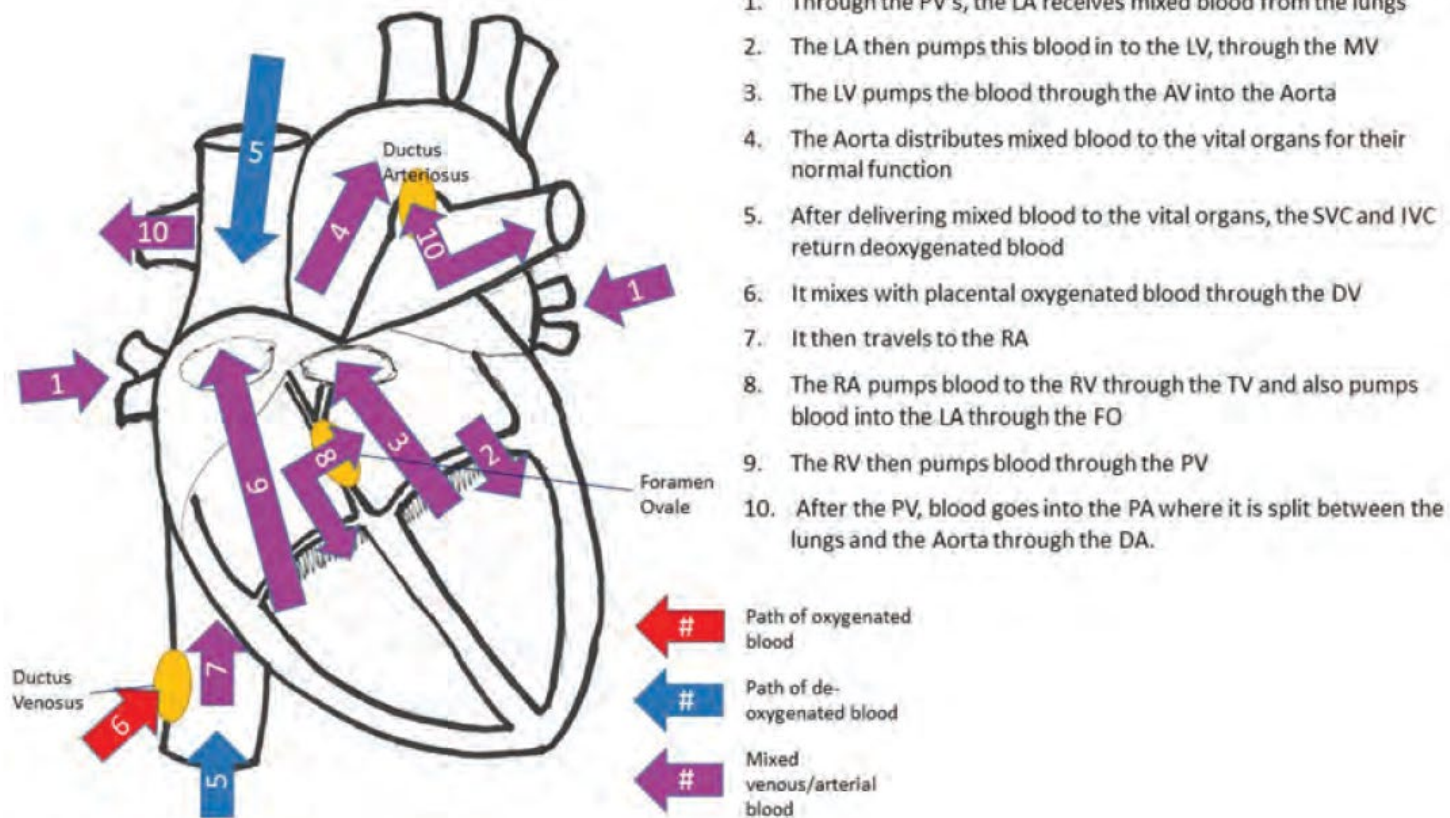
Figure 1 Normal Newborn/Adult Circulation



1. Through the Pulmonary Veins (PV), the Left Atrium (LA) receives oxygenated blood from the lungs
2. The LA then pumps blood in to the Left Ventricle (LV), through the Mitral Valve (MV)
3. The LV pumps blood through the Aortic Valve (AV) into the Aorta
4. The Aorta distributes blood to the vital organs for their normal function
5. Oxygen poor blood returns to the Right Atrium (RA) via the Superior Vena Cava (SVC) and Inferior Vena Cava (IVC)
6. The RA pumps blood to the Right Ventricle (RV) through the Tricuspid Valve (TV)
7. The RV then pumps blood through the Pulmonic Valve (PV)
8. After the PV blood enters the Pulmonary Arteries (PA) (8) which carry deoxygenated blood to the lungs starting the process over again.

Normal Fetal Circulation

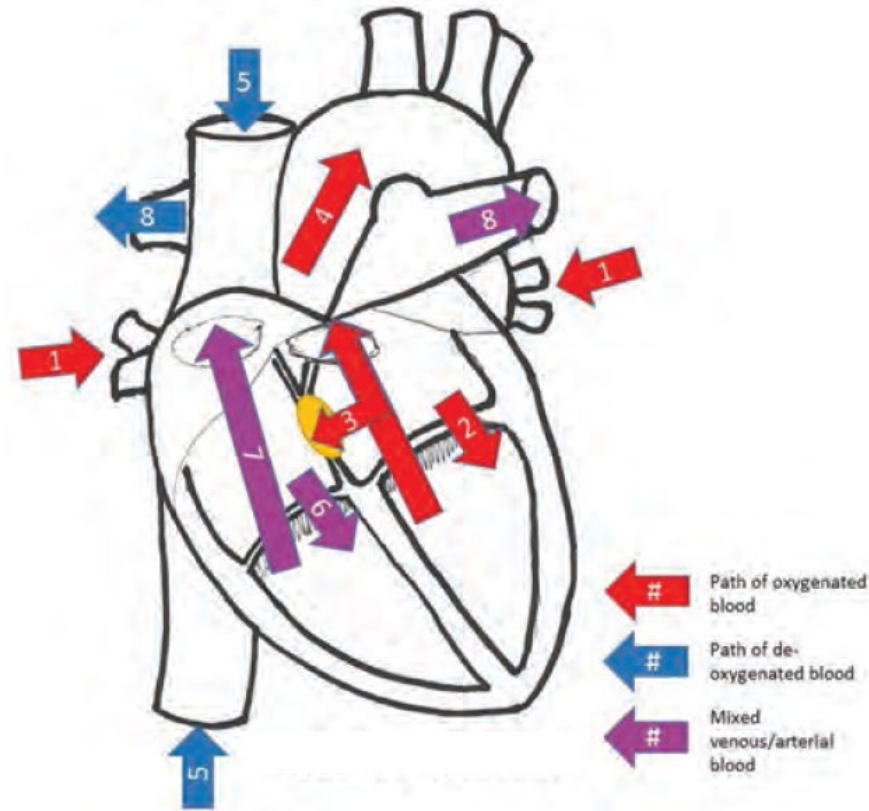
Figure 2 Normal Fetal Circulation



1. Through the PV's, the LA receives mixed blood from the lungs
2. The LA then pumps this blood in to the LV, through the MV
3. The LV pumps the blood through the AV into the Aorta
4. The Aorta distributes mixed blood to the vital organs for their normal function
5. After delivering mixed blood to the vital organs, the SVC and IVC return deoxygenated blood
6. It mixes with placental oxygenated blood through the DV
7. It then travels to the RA
8. The RA pumps blood to the RV through the TV and also pumps blood into the LA through the FO
9. The RV then pumps blood through the PV
10. After the PV, blood goes into the PA where it is split between the lungs and the Aorta through the DA.

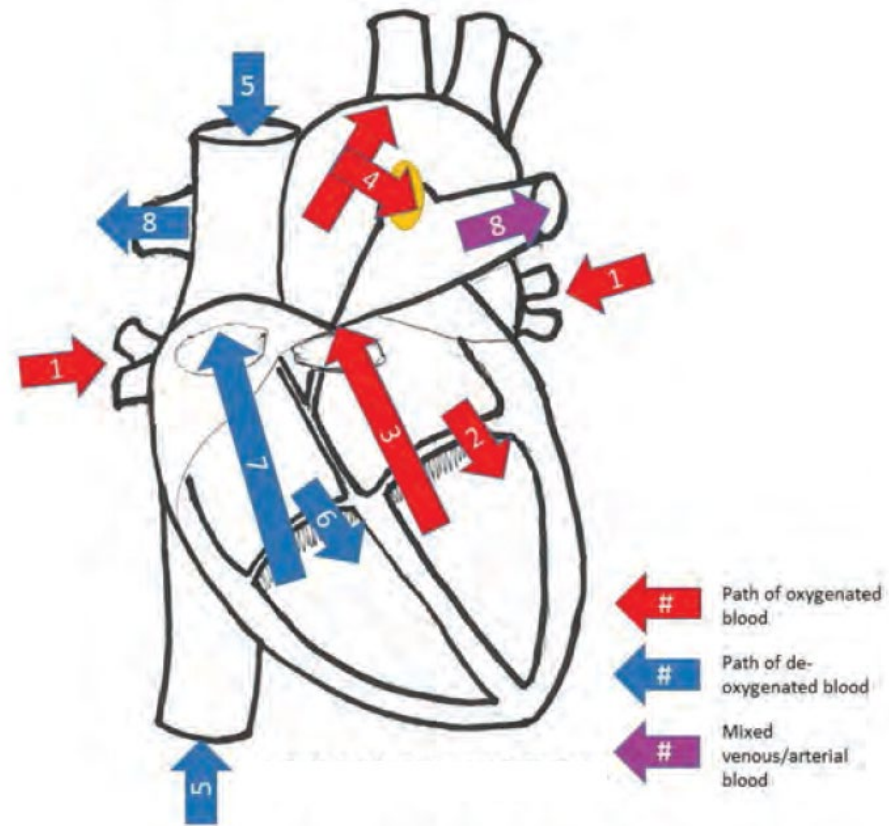
Atrial Septal Defect

Figure 3 Atrial Septal Defects (ASD)



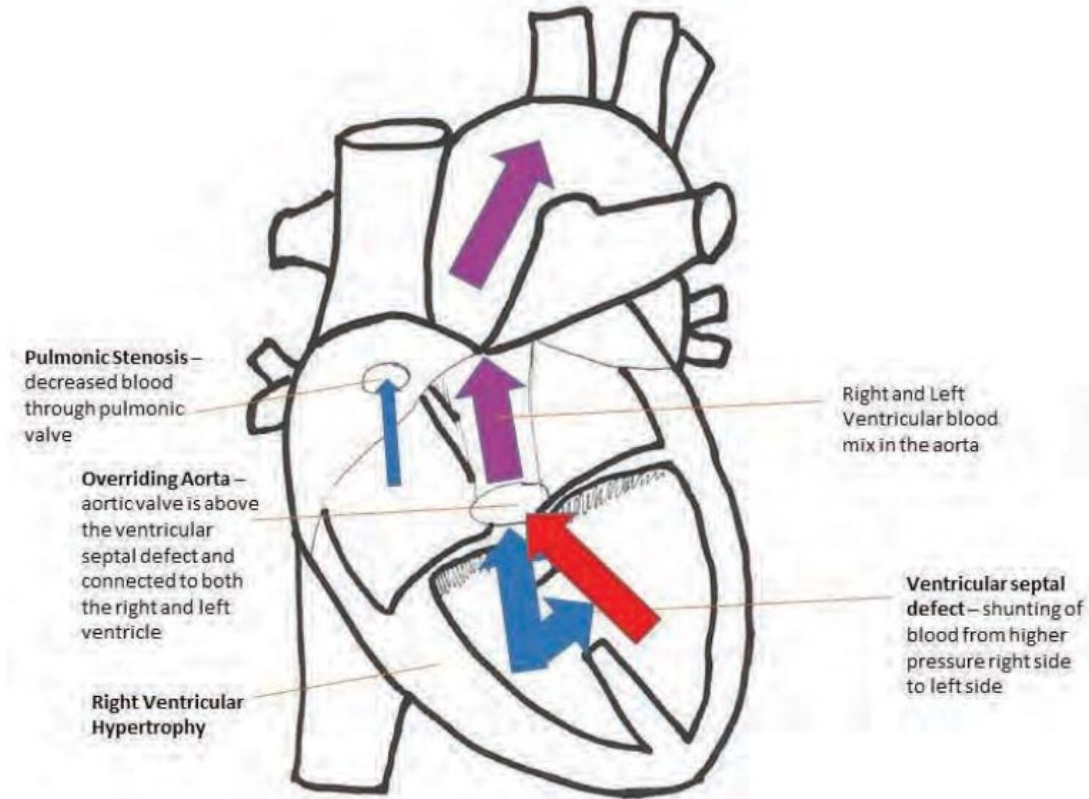
Patent Ductus Arteriosus

Figure 4 Patent Ductus Arteriosus (PDA)

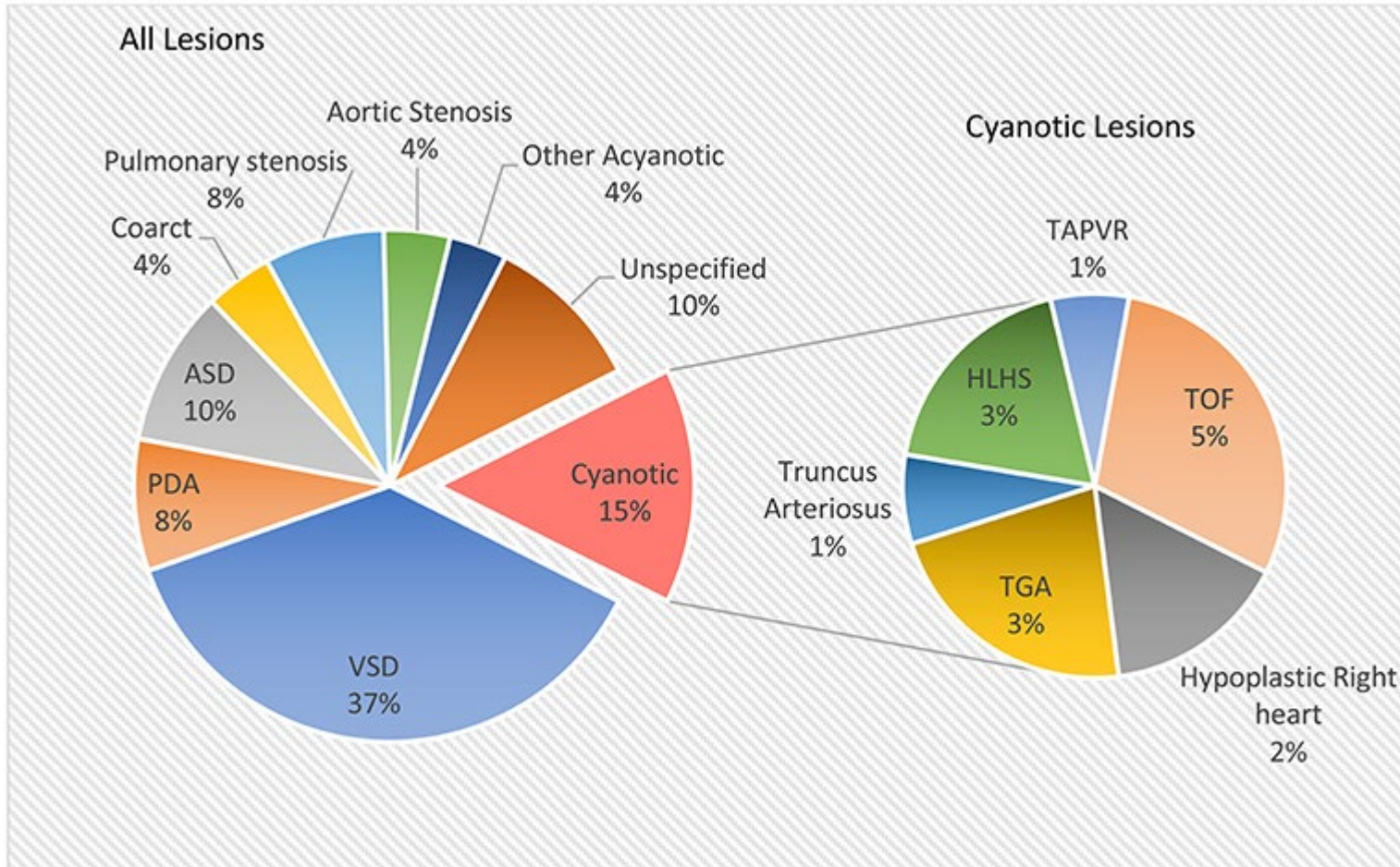


Tetralogy of Falot

Figure 3 Tetralogy of Fallot (TOF)

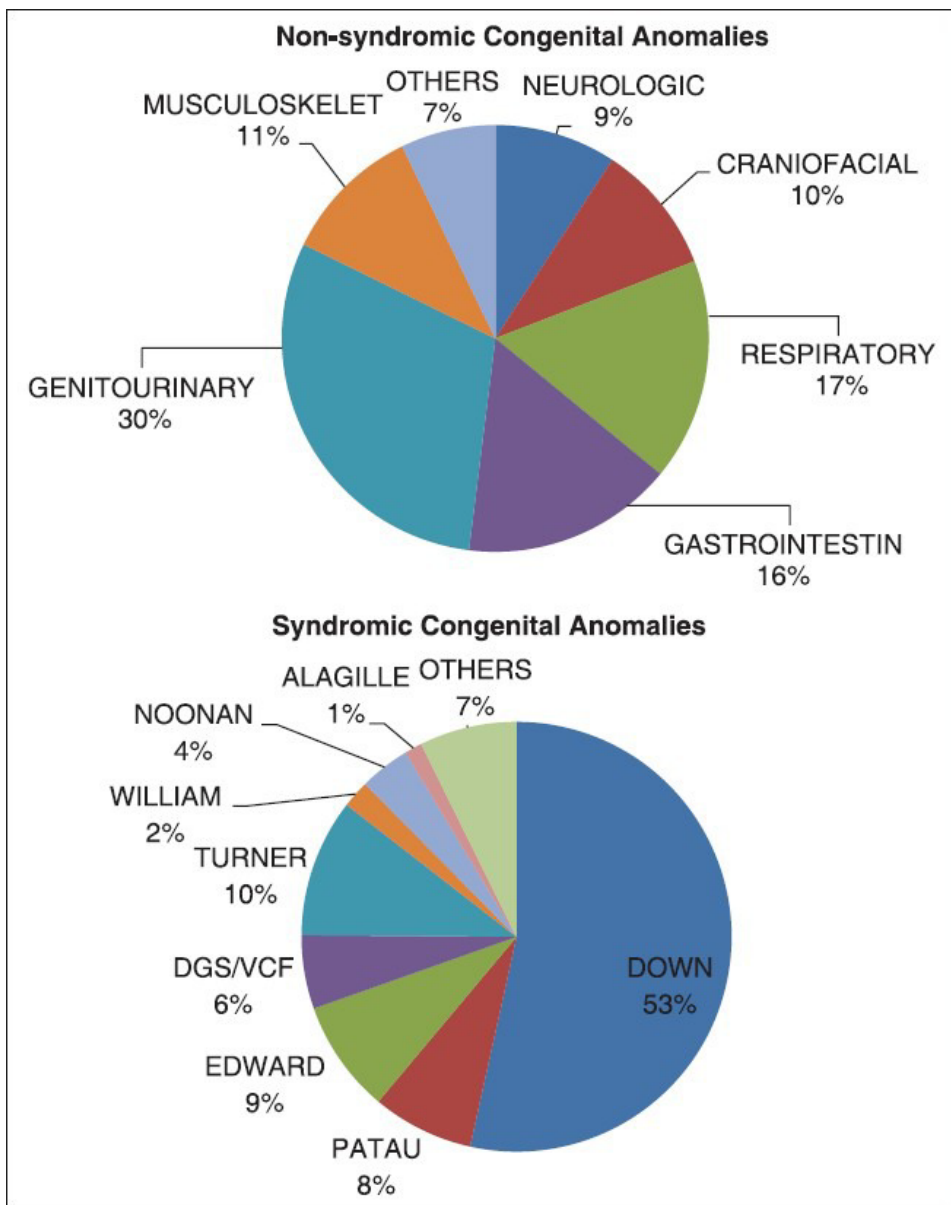


Congenital Heart Lesions



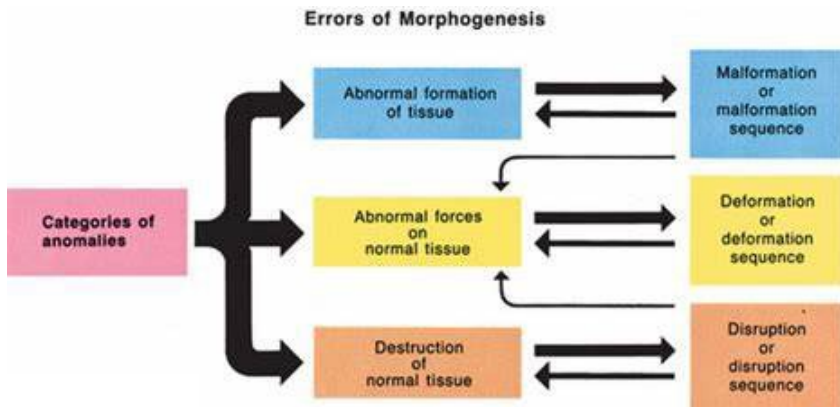
Complexity	Native disease	Repaired conditions
Simple	<ul style="list-style-type: none"> Isolated small atrial septal defect (ASD) Isolated small ventricular septal defect (VSD) Mild isolated pulmonic stenosis 	<ul style="list-style-type: none"> Previously ligated or occluded ductus arteriosus Repaired secundum ASD or sinus venosus defect without significant residual shunt or chamber enlargement Repaired VSD without significant residual shunt or chamber enlargement
Moderate Complexity	Repaired or unrepaired conditions <ul style="list-style-type: none"> Anomalous pulmonary venous connection, partial or total Atrioventricular (AV) septal defect (partial or complete) Coarctation of the aorta Ebstein anomaly (including mild, moderate, and severe variations) Infundibular RV outflow obstruction Repaired tetralogy of fallot (TOF) VSD with associated abnormality and/or moderate or greater shunt 	Valve (or near-valve) conditions <ul style="list-style-type: none"> Pulmonary valve regurgitation (moderate or greater) Pulmonary valve stenosis (moderate or greater) Subvalvular aortic stenosis (excluding hypertrophic cardiomyopathy) Supravalvular aortic stenosis Congenital aortic valve disease Congenital mitral valve disease
Great Complexity (or Complex)	<ul style="list-style-type: none"> Cyanotic congenital heart defect (unrepaired or palliated, all forms) Double-outlet ventricle Fontan procedure Interrupted aortic arch Truncus arteriosus 	<ul style="list-style-type: none"> Single Ventricle (including double inlet left ventricle, tricuspid atresia, hypoplastic left heart) Pulmonary atresia Mitral atresia Transposition of the great arteries (TGA)

Congenital Heart with other anomalies/syndromes



Egbe, Alexander & Lee, Simon & Ho, Deborah & Uppu, Santosh & Srivastava, Shubhika. (2014). Prevalence of congenital anomalies in newborns with congenital heart disease diagnosis. *Annals of pediatric cardiology*. 7. 86-91. 10.4103/0974-2069.132474.

Morphogenesis



Malformation

Etiology: Chromosomal, Genetic, Teratogenic, Unknown

Morphogenic error → Developing structure → Primary structural defect

Failure of neural tube closure → Myelomeningocele (malformation)

Malformation. Primary structural defect resulting from error in tissue formation

Deformation

Etiology: Extrinsic (fetal constraint), Intrinsic (fetal akinesia)

Abnormal force → Normally developed structure → Altered structure or position

Intrauterine force → Clubfoot (deformation)

Deformation. Alteration in shape or position of normally developed structure

Disruption

Etiology: Vascular, Compressive, Tearing

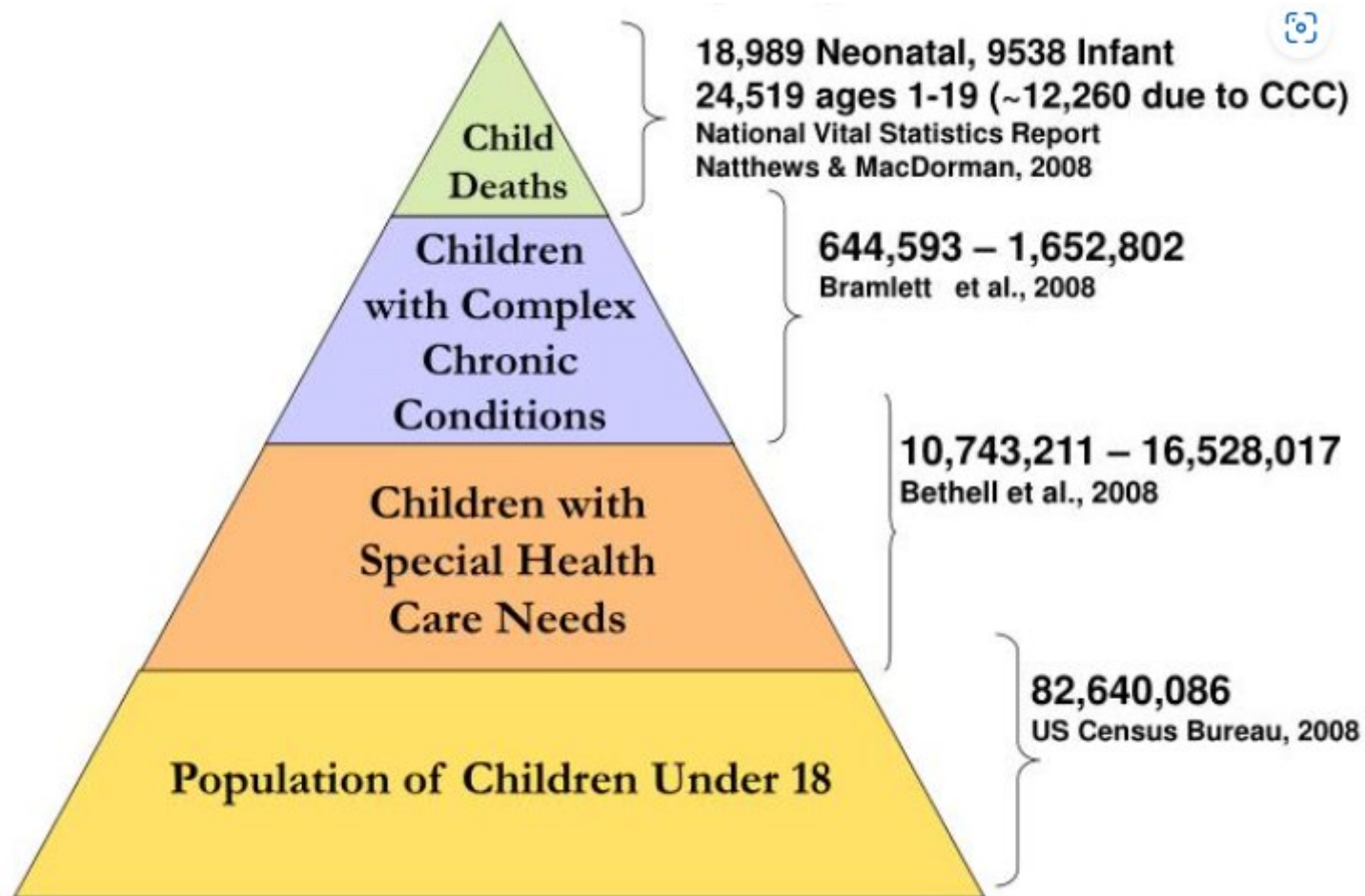
Vascular occlusion, Abnormal force → Normally developed structure → Tissue destruction

Destructive forces → Limb reduction deficit (disruption)

Disruption. Destruction of previously normally developed structure

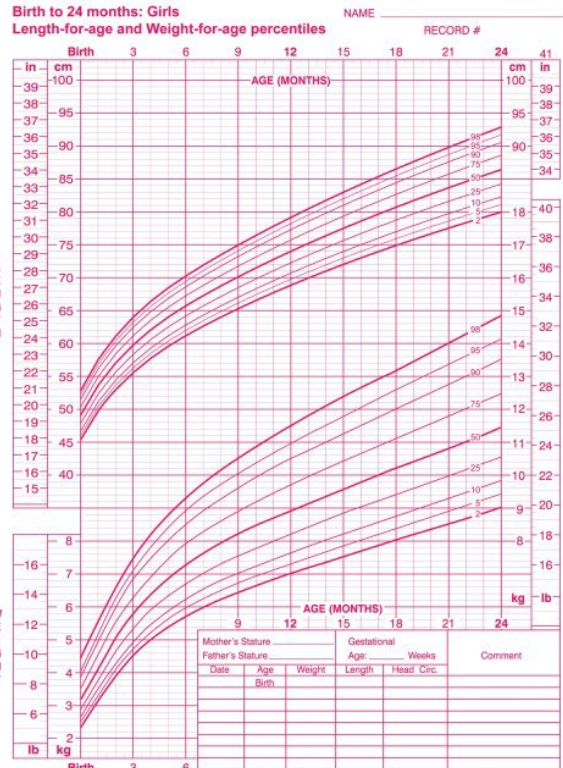
JOHN A. CRAIG, MD
© 2004-2007

Complex Health Conditions and Special Needs



GROWTH

Periods of Growth and Development



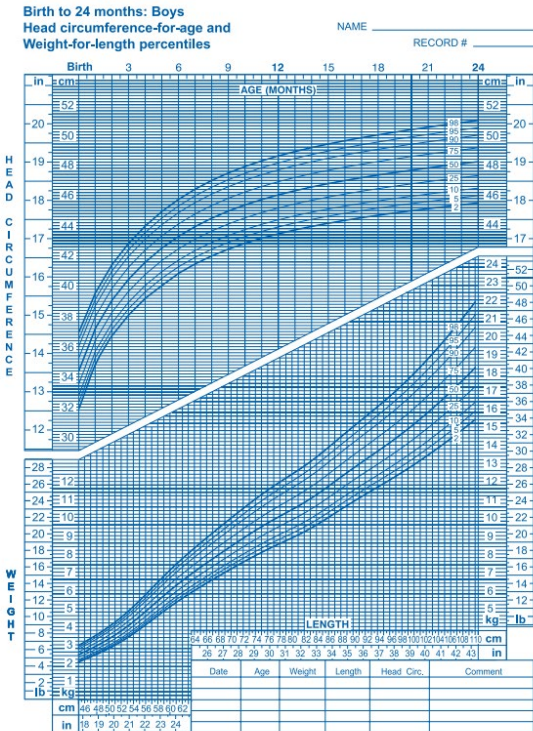
Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (<http://www.who.int/childgrowth/>)



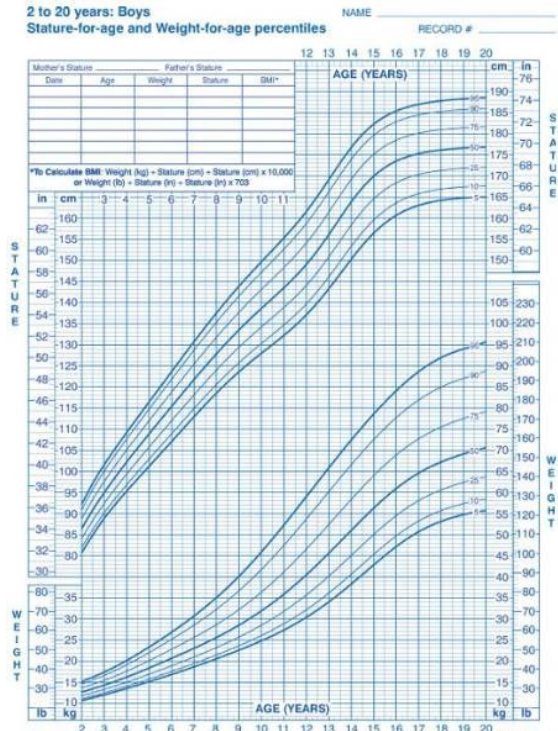
Published May 30, 2000.
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).



Figure 10. Individual growth chart 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 97th percentiles, 2 to 20 years: Girls weight-for-age



Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (<http://www.who.int/childgrowth/>)

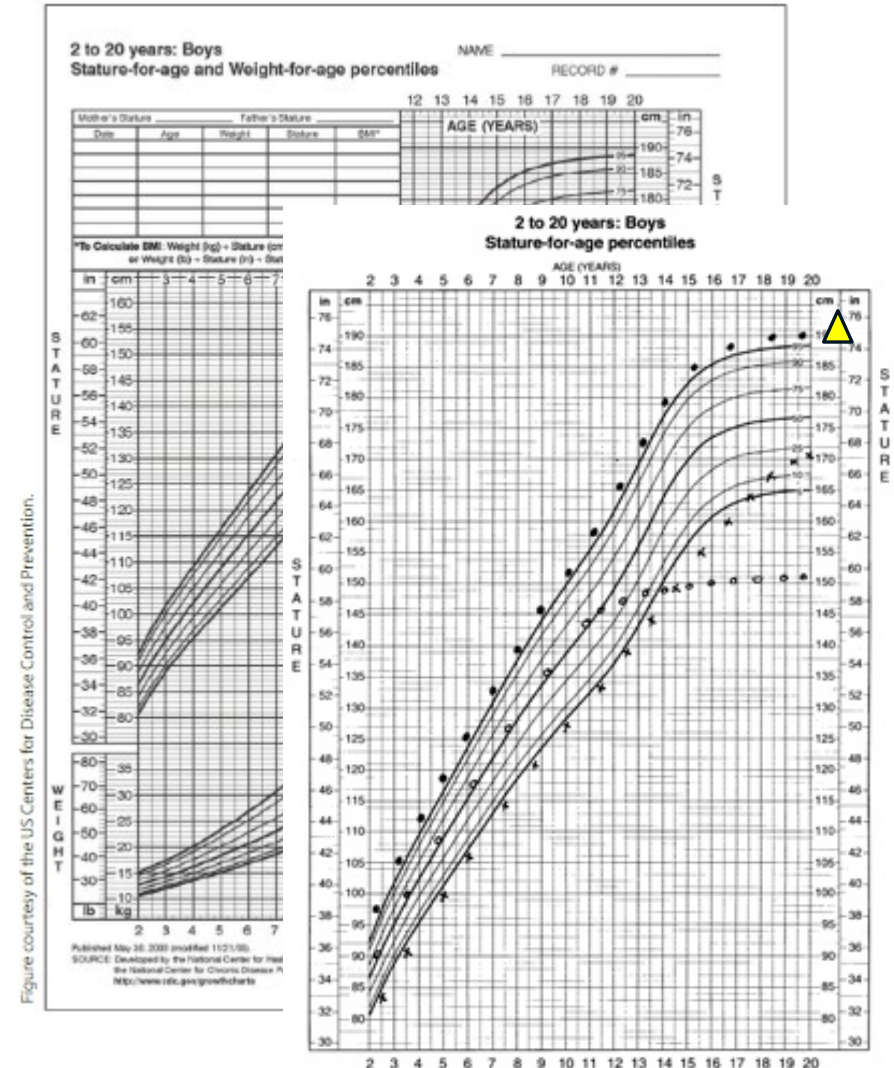


Published May 30, 2000 (modified 11-01-00)
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
<http://www.cdc.gov/growthcharts>



Growth Charts Can be Abnormal

- 11-year-old male applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits and sick visits.
- He has always been a **picky eater**; had **irritability and fussiness** in infancy. Medical records suggest that there were **multiple formula changes**.
- He is on a **regular diet now**.
- Recently, he has **started missing meals in school**.
- He has had multiple of his **sick visits focused on abdominal pain**. No nausea, vomiting, diarrhea or constipation.
- He had one episode of **knee pain associated with playing soccer** that resolved with NSAIDs.
- **Parental heights** are 5'5" for the father and 5' for the mother.
- Growth curve was included in the chart.

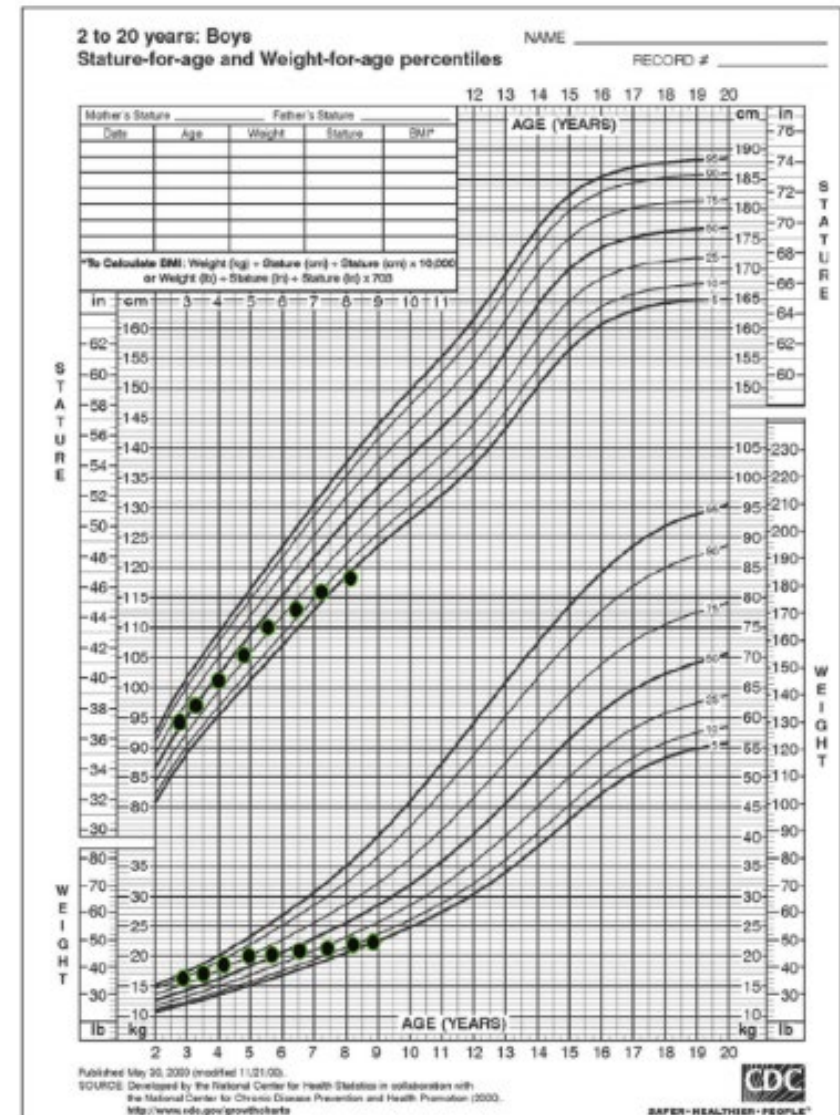


Nwosu, Benjamin & Lee, Mary. (2008). Evaluation of short and tall stature in children. American family physician. 78. 597-604.

Garganta, Melissa & Bremer, Andrew. (2014). Clinical Dilemmas in Evaluating the Short Child. Pediatric annals. 43. 321-327. 10.3928/00904481-20140723-11.

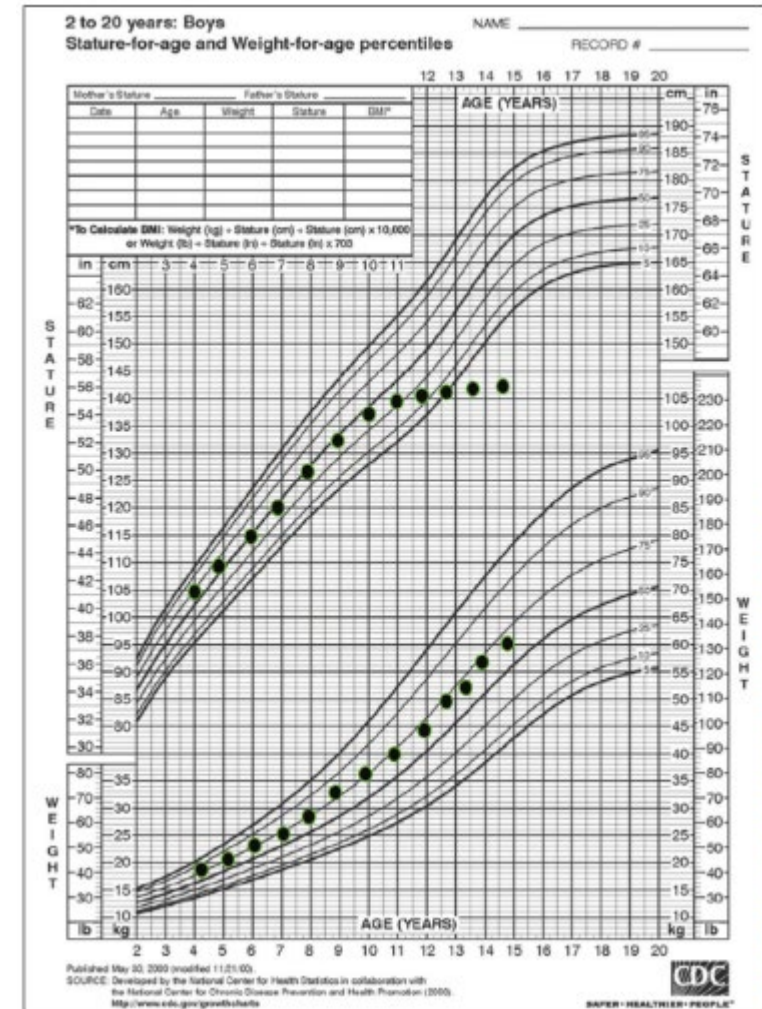
Growth Charts Can be Abnormal

- 6-year-old male applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits and sick visits.
- He has always been a **picky eater**; had **irritability and fussiness** in infancy. Medical records suggest that there were **multiple formula changes**.
- He is on a **regular diet now**.
- Recently, he has **started missing meals in school**.
- Mom noted in the records with pediatrician that he has a bit of a **“pot belly, but that’s the way dad looks.”**
- He has had multiple of his **sick visits focused on abdominal pain**. No nausea or vomiting, but **multiple episodes of diarrhea**.
- He had one episode of **mono-articular arthritis of the knee** when he was 3 years of age, but that resolved with NSAIDs.
- Growth curve was included in the chart.



Growth Charts Can be Abnormal

- 11-year-old male applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits and sick visits.
- He has always been a **picky eater**; had **irritability and fussiness** in infancy. Medical records suggest that there were **multiple formula changes**.
- He is on a **regular diet now**.
- Recently, he has **started missing meals in school**.
- He has had multiple of his **sick visits focused on abdominal pain**. No nausea, vomiting, or diarrhea. There has been recent report of **constipation**.
- Over the course of the past year he has been reporting **fatigue, low energy**
- He has increasing report of vague **muscle aches** that do not respond to NSAIDs.
- Mom is concerned because he seems to be more **socially isolated and moody**.
- Growth curve was included in the chart.



Growth Charts Can be Abnormal

- 11-year-old male applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits and sick visits.
- He has always been a **picky eater**; had **irritability and fussiness** in infancy. Medical records suggest that there were **multiple formula changes**.
- He is on a **regular diet now**.
- Recently, he has **started missing meals in school**.
- He has had multiple of his **sick visits focused on abdominal pain**. No nausea, vomiting, diarrhea or constipation.
- He had one episode of **knee pain associated with playing soccer** that resolved with NSAIDs.
- **Parental heights** are 5'8" for the father and 5'3" for the mother.
- Growth curve was included in the chart.

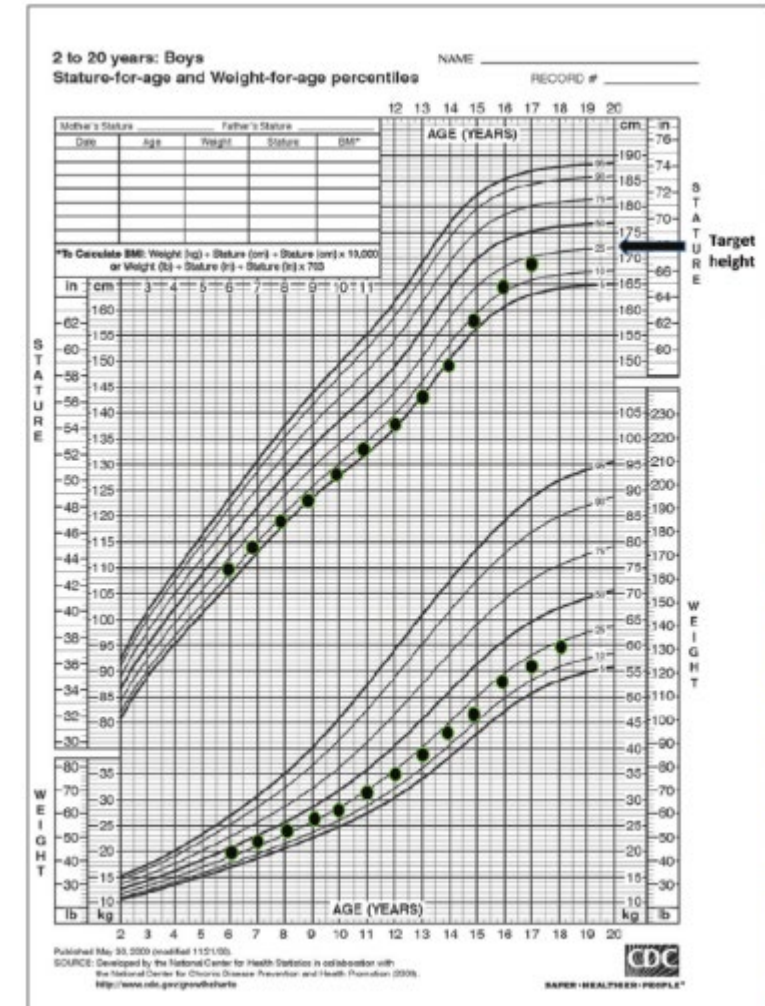
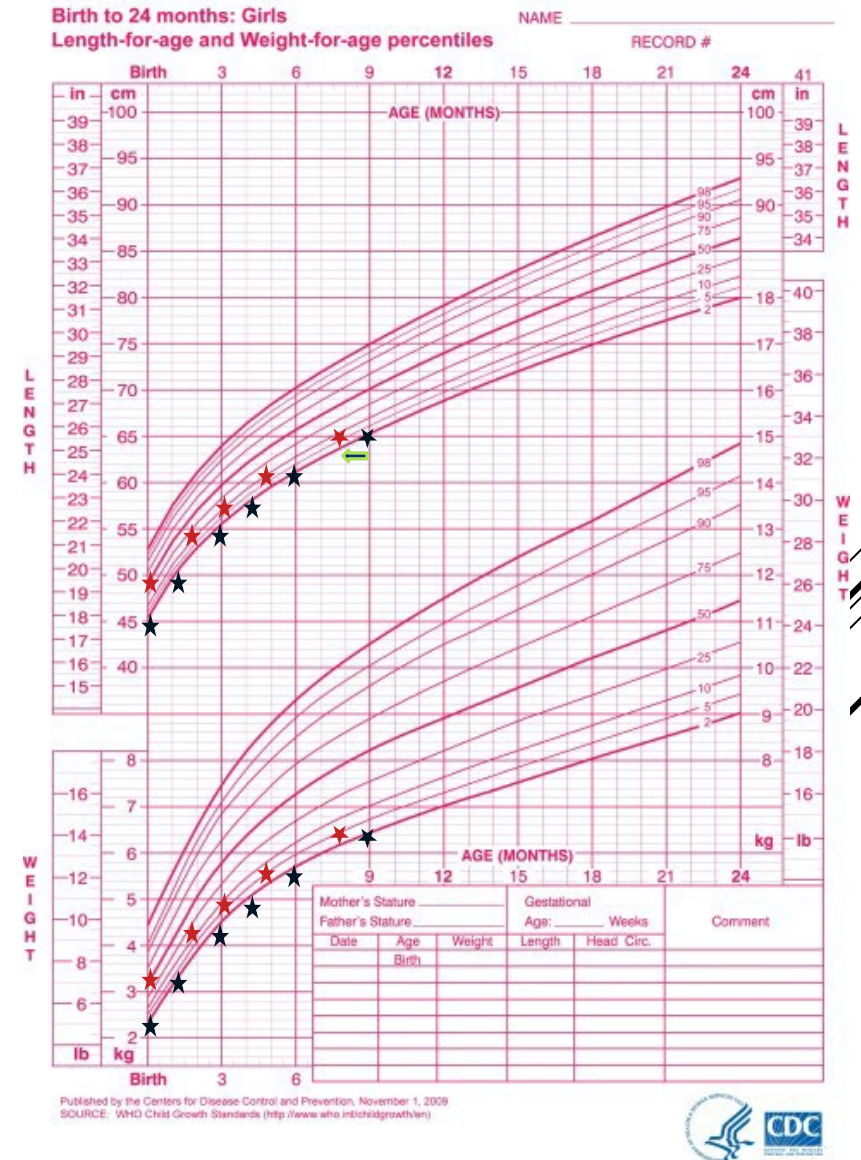


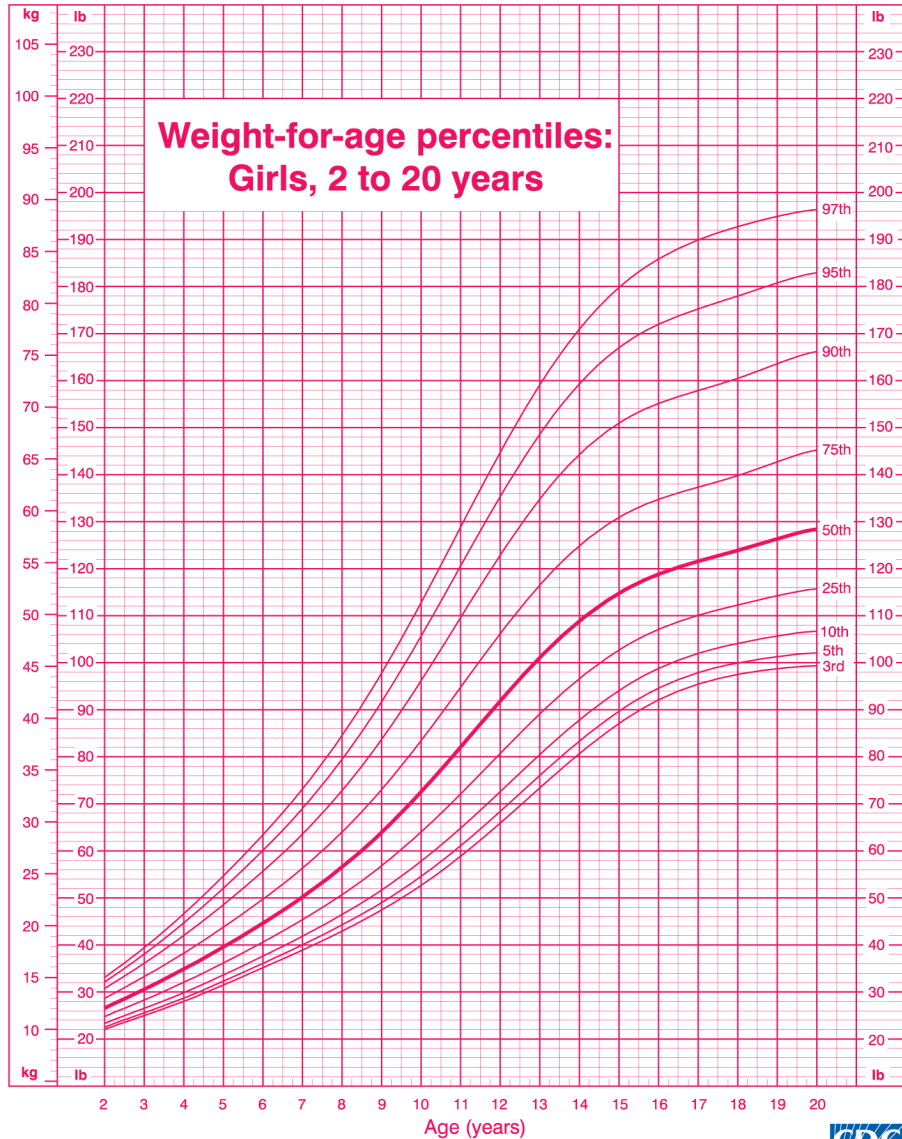
Figure courtesy of the US Centers for Disease Control and Prevention.

Growth Charts Can be Abnormal

- 9-month-old female applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits.
- She was a **35-week-premie** but just stayed in the nursery for **feeding and growth** for a total of a week.
- She has always been a **picky eater**; had **irritability and fussiness** in early infancy. Medical records suggest that there were **a couple formula changes**.
- Mom noted in the records with pediatrician that he has a bit of a **“big nose, but that’s the way dad looks.”**
- Growth curve for head was included in the chart.



Special Growth Curves for Special Circumstances



Published May 30, 2000.

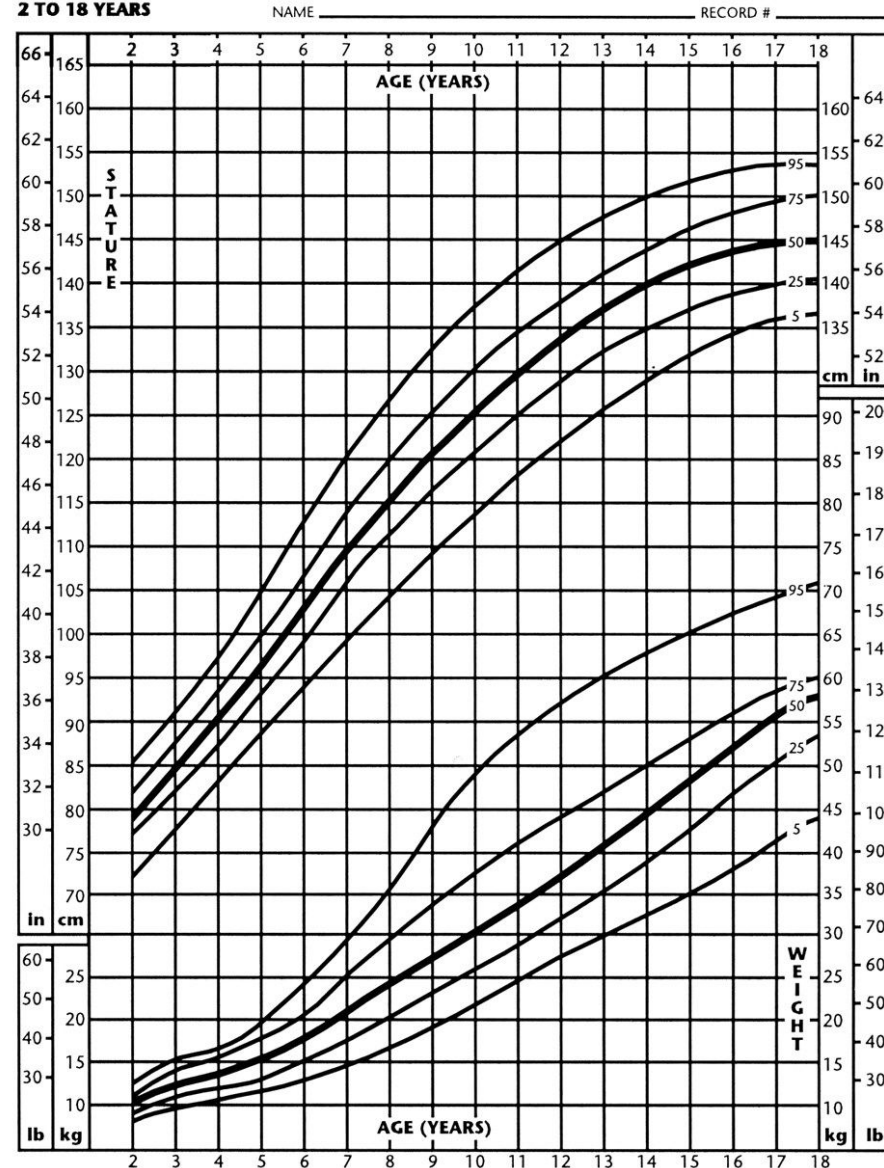
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).



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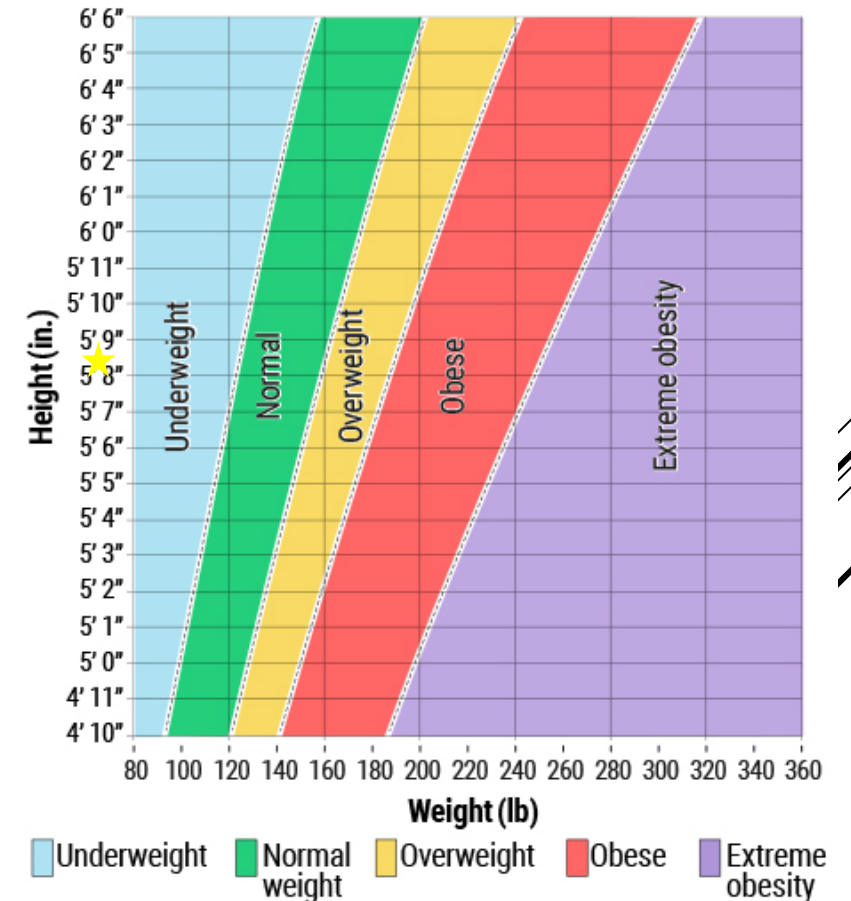
Figure 10. Individual growth chart 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 97th percentiles, 2 to 20 years: Girls weight-for-age

**GIRLS WITH DOWN SYNDROME
PHYSICAL GROWTH:
2 TO 18 YEARS**



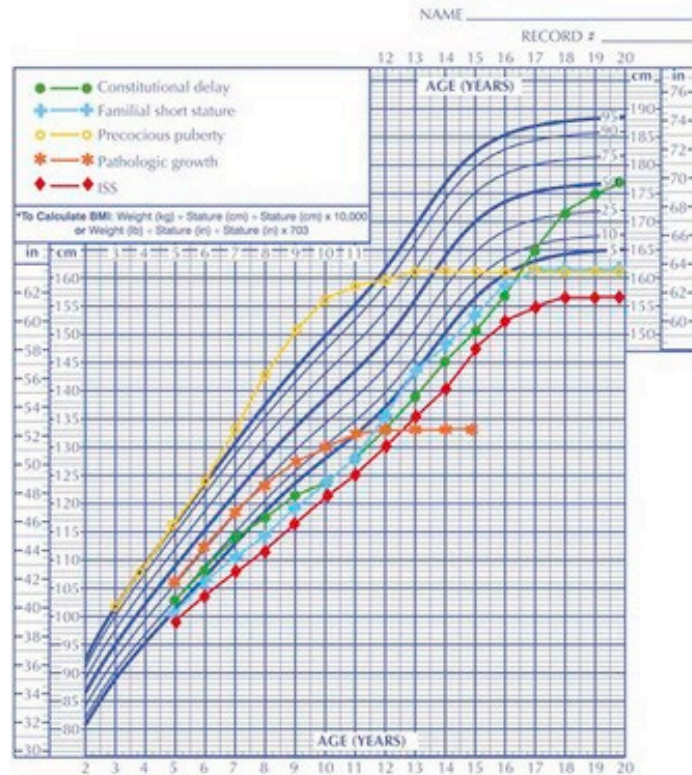
Growth Charts Can be Abnormal

- 16-year-old female applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits.
- She has always been a **picky eater**; had **irritability and fussiness** in infancy. Medical records suggest that there were **multiple formula changes**.
- She is on a **regular diet now**.
- Recently, she has **started missing meals in school**.
- Over the course of the past year she has been reporting **fatigue**.
- She has increasing report of vague **muscle aches** that do not respond to NSAIDs.
- Mom is concerned because she seems to be more **socially isolated and moody**. This is compounded by the fact that **parents are finalizing a divorce** and a **recent breakup with her boyfriend**.
- She is 5'8" and weighs 95lbs. Her arms are covered with lanugo and she has poorly developed female sexual characteristics.
- Growth curve was included in the chart.



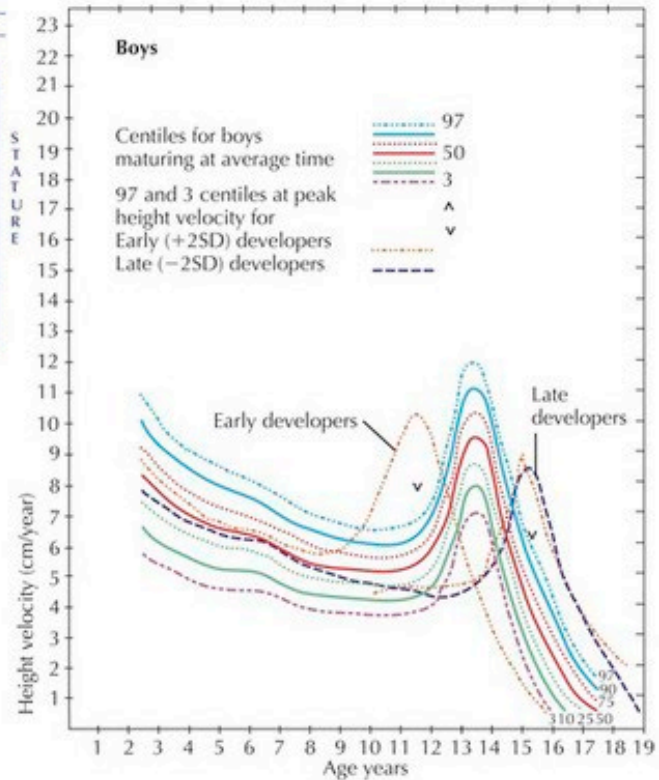
Final Thoughts about Growth

CDC 2000 Growth Curve: Boys ages 2-20 years



Published May 30, 2000 (modified 11/21/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). <http://www.cdc.gov/growthcharts>

Tanner Height Velocity Curves for Boys



From Tanner JM, Davies PSW. Clinical longitudinal standards for height and weight velocity for North American children. *Journal of Pediatrics* 1985;107(3):317-329.

Genetics:	Nutrition:	Psychosocial:	Systemic illness:	Medications:	Endocrine:
<ul style="list-style-type: none"> Turner syndrome Down syndrome Noonan syndrome SHOX haploinsufficiency Skeletal dysplasias Others 	<ul style="list-style-type: none"> Undernutrition Eating disorders Celiac disease IBD Other forms of malabsorption GERD Fe or Zinc deficiency 	<ul style="list-style-type: none"> Deprivation dwarfism 	<ul style="list-style-type: none"> HIV/AIDS TB Cystic fibrosis Cancer Congenital heart disease (esp. cyanotic) Renal disease Acidosis Chronic liver disease 	<ul style="list-style-type: none"> Stimulants (for ADHD treatment) Glucocorticoids Chemotherapy and/or radiation 	<ul style="list-style-type: none"> Hypothyroidism Growth hormone deficiency IGF deficiency Puberty variants Endogenous glucocorticoid excess

DEVELOPMENT

Pediatric Milestones

TABLE 1

Criteria for Developmental Milestones and Surveillance Tools.

1. Milestones are included at the age most ($\geq 75\%$) children would be expected to demonstrate the milestone
2. Eliminate "warning signs" ^a
3. Are easy for families of different social, cultural, and ethnic backgrounds to observe and use
4. Are able to be answered with yes, not yet, or not sure
5. Use plain language, avoiding vague terms like may, can, and begins
6. Are organized in developmental domains
7. Show progression of skills with age, when possible
8. Milestones are not repeated across checklists
9. Include open-ended questions
10. Include information for developmental promotion
11. Include information on how to act early if there are concerns

Criteria developed by SMEs.

a Milestones listed separately within CDC materials with parent messaging to act early if child has not attained them.

Pediatric Social-Emotional Milestones

Social-Emotional Milestones With Supporting Normative Data, Evaluation Tools, and Published Clinical Opinion References

Social-Emotional Milestones	Age
Calms down when spoken to or picked up ^d	2 mo
Looks at your face	2 mo
Seems happy to see you when you walk up to her	2 mo
Smiles when you talk to or smile at her	2 mo
Smiles on his own to get your attention	4 mo
Chuckles (not yet a full laugh) when you try to make her laugh	4 mo
Looks at you, moves, or makes sounds to get or keep your attention	4 mo
Knows familiar people	6 mo
Likes to look at himself in the mirror	6 mo
Laughs	6 mo
Is shy, clingy, or fearful around strangers	9 mo
Shows several facial expressions, like happy, sad, angry, and surprised ^d	9 mo
Looks when you call his name	9 mo
Reacts when you leave (looks, reaches for you, or cries) ^d	9 mo
Smiles or laughs when you play peek-a-boo	9 mo
Plays games with you, like pat-a-cake	12 mo
Copies other children while playing, like taking toys out of a container when another child does ^d	15 mo
Shows you an object that he likes	15 mo
Claps when excited	15 mo
Hugs stuffed doll or other toy	15 mo
Shows you affection (hugs, cuddles, or kisses you)	15 mo
Moves away from you, but looks to make sure you are close by	18 mo
Points to show you something interesting	18 mo
Puts hands out for you to wash them	18 mo
Looks at a few pages in a book with you ^d	18 mo

Social-Emotional Milestones	Age	Screening and Evaluation Tools ^b	Published Clinical Opinion ^c
Calms down when spoken to or picked up ^d	2 mo		ASHA (11), Bright Futures (36), Dosman et al (8), Sharp et al (37)
Looks at your face	2 mo		Bright Futures (36), Dosman et al (8), Scharf et al (18)
Seems happy to see you when you walk up to her	2 mo		—
Smiles when you talk to or smile at her	2 mo	ASQ (25)	ASHA (11)
Smiles on his own to get your attention	4 mo		Bright Futures (36)
Chuckles (not yet a full laugh) when you try to make her laugh	4 mo		ASHA (11), Bellman et al (42), Bright Futures (36)
Looks at you, moves, or makes sounds to get or keep your attention	4 mo		—
Knows familiar people	6 mo		Bright Futures (36), Dosman et al (8), Gerber et al (20), Scharf et al (18)
Likes to look at himself in the mirror	6 mo		Bright Futures (36)
Laughs	6 mo		Bellman et al (42), Bright Futures (36), Dosman et al (8)
Is shy, clingy, or fearful around strangers	9 mo		Gerber et al (20), Scharf et al (18)
Shows several facial expressions, like happy, sad, angry, and surprised ^d	9 mo		Gerber et al (20), Scharf et al (18)
Looks when you call his name	9 mo		Bright Futures (36) Dosman et al (8), Gerber et al (20), Scharf et al (18)
Reacts when you leave (looks, reaches for you, or cries) ^d	9 mo		Dosman et al (8), Gerber et al (20), Scharf et al (18)
Smiles or laughs when you play peek-a-boo	9 mo		Bellman et al (42), Bright Futures (36), Dosman et al (8), Gerber et al (20), Scharf et al (18)
Plays games with you, like pat-a-cake	12 mo		Bellman et al (42), Bright Futures (36), Gerber et al (20), Scharf et al (18)
Copies other children while playing, like taking toys out of a container when another child does ^d	15 mo		Bright Futures (36), Dosman et al (8)
Shows you an object that he likes	15 mo		Dosman et al (8), First Words (14), Gerber et al (20), Scharf et al (18)
Claps when excited	15 mo		—
Hugs stuffed doll or other toy	15 mo		Colson and Dworkin (16), Johnson and Blasco (15)
Shows you affection (hugs, cuddles, or kisses you)	15 mo	ASQ III (27)	Johnson and Blasco (15), Vaughan (17)
Moves away from you, but looks to make sure you are close by	18 mo		Dosman et al (8), Gerber et al (20), Scharf et al (18)
Points to show you something interesting	18 mo		(24), PEDS-DM
Puts hands out for you to wash them	18 mo		Bellman et al (42), Bright Futures (36), Dosman et al (8), Gerber et al (20), Scharf et al (18)
Looks at a few pages in a book with you ^d	18 mo		—
Calms down when spoken to or picked up ^d	2 mo		Behrman et al (50), Colson and Dworkin (16), Vaughan (17)
Looks at your face	2 mo		
Seems happy to see you when you walk up to her	2 mo		
Smiles when you talk to or smile at her	2 mo		
Smiles on his own to get your attention	4 mo		
Chuckles (not yet a full laugh) when you try to make her laugh	4 mo		
Looks at you, moves, or makes sounds to get or keep your attention	4 mo		
Knows familiar people	6 mo		
Likes to look at himself in the mirror	6 mo		
Laughs	6 mo		
Is shy, clingy, or fearful around strangers	9 mo		
Shows several facial expressions, like happy, sad, angry, and surprised ^d	9 mo		
Looks when you call his name	9 mo		
Reacts when you leave (looks, reaches for you, or cries) ^d	9 mo		
Smiles or laughs when you play peek-a-boo	9 mo		
Plays games with you, like pat-a-cake	12 mo		

Pediatric Language, Cognitive and Motor Milestones

Language and Communication Milestones With Supporting Normative Data, Evaluation Tools, and Published Clinical Opinion References

Language/Communication Milestones	Age	CDC or New	Source		
			Normative Data ^a	Developmental Screening and Evaluation Tools ^b	Published Clinical Opinion ^c
Makes sounds other than crying	2 mo	CDC	Dosman et al (8), ^d Sheldrick and Perrin (38)	ASQ-3 (22), PEDS-DM (25)	Blackwell and Baker (53), Bright Futures (36), Gerber et al (20), Scharf et al (18)
Reacts to loud sounds ^e	2 mo	New	—	—	Accardo and Capute (30), ASHA (11), Bellman et al (42), Bright Futures (36)

Makes sound Cognitive Milestones With Supporting Normative Data, Evaluation Tools, and Published Clinical Opinion References











Cognitive Milestones	Age	CDC or New	Source		
			Normative Data ^a	Developmental Screening and Evaluation Tools ^b	Published Clinical Opinion ^c
Turns head to	2 mo	CDC	Accardo and Capute (30), Atkinson et al (60), Bhawe et al (40), Ertem et al (35), Sheldrick and Perrin (38)	ASQ-3 (22)	—
Takes turns n	?	New	Kumar et al (44)	—	Accardo and Capute (30), Bellman et al (42)








Looks at a toy for several seconds Motor Milestones With Supporting Normative Data, Evaluation Tools, and Published Clinical Opinion References

Motor Milestones	Age	CDC or New	Source		
			Normative Data ^a	Developmental Screening and Evaluation Tools ^b	Published Clinical Opinion ^c
Looks at his han	2 mo	CDC	Accardo and Capute (30), Carruth and Skinner (61), Den Ouden et al (54)	—	Bright Futures (36), Dosman et al (8), Gerber et al (20), Scharf et al (18)
Puts things in he	2 mo	New	—	ASQ-3 (22)	Bright Futures (36)
Opens hands briefly	2 mo	New	Accardo and Capute (30), Ertem et al (35), Lejarraga et al (41)	ASQ-3	Bright Futures (36)
Holds head steady without support when you are holding her	4 mo	CDC	Ertem et al (35), Lejarraga et al (41), Sheldrick and Perrin (38)	PEDS-DM (25)	Bright Futures (36), Gerber et al (20), Scharf et al (18)
Holds a toy when you put it in his hand	4 mo	CDC	Dosman et al (8) ^d	—	Bellman et al (42), Gerber et al (20), Scharf et al (18)
Uses her arm to swing at toys	4 mo	CDC	Bhawe et al (40), Dosman et al (8), Ertem et al (43), Kumar et al (44)	—	Gerber et al (20), Scharf et al (18)

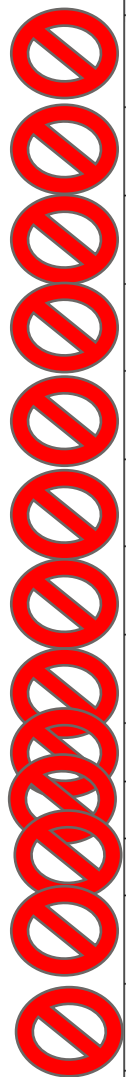
Development

- 3-year-old female applicant for life insurance presents **clean-sheeted**.
- There have been **no hospitalizations**, but multiple primary care visits for well visits.
- She has always been a **picky eater**; had **irritability and fussiness** in early infancy. Medical records suggest that there were **a couple formula changes**.
- She is on a **regular diet now**.
- Recently, she has **started missing meals in school** because she has been having temper tantrums of increasing escalation she has. She will often wring her hands or flap her arms when things don't go her way.
- Mom noted in the records with pediatrician that she is a bit shy and doesn't say much, **"but that's the way dad is."**
- Developmental questions were asked of the mother.

Motor Milestones	Age
 Kicks a ball	24 mo
 Runs	24 mo
 Walks (not climbs) up a few stairs with or without help	24 mo
 Eats with a spoon	24 mo
 Uses hands to twist things, like turning doorknobs or unscrewing lids	30 mo
 Takes some clothes off by himself, like loose pants or an open jacket	30 mo
 Jumps off the ground with both feet	30 mo
 Turns book pages, 1 at a time, when you read to her	30 mo
 Strings items together, like large beads or macaroni	3 y
 Puts on some clothes by himself, like loose pants or a jacket	3 y

Social-Emotional Milestones	Age
 Notices when others are hurt or upset, like pausing or looking sad when someone is crying	24 mo
 Looks at your face to see how to react in a new situation	24 mo
 Plays next to other children and sometimes plays with them	30 mo
 Shows you what she can do by saying, "Look at me!"	30 mo
 Follows simple routines when told, like helping to pick up toys when you say, "It's clean-up time."	30 mo
 Calms down within 10 min after you leave her, like at child care drop off ^d	3 y
 Notices other children and joins them to play	3 y

Development



Language/Communication Milestones	Age
Points to things in a book when you ask, for example, "Where is the bear?"	24 mo
Says at least 2 words together, like "More milk."	24 mo
Points to at least 2 body parts when you ask him to show you	24 mo
Uses more gestures than just waving and pointing, like blowing a kiss or nodding yes	24 mo
Says ~50 words	30 mo
Says ≥2 words, with 1 action word, like "Doggie run."	30 mo
Names things in a book when you point and ask, "What is this?"	30 mo
Says words like I, me, or we	30 mo
Talks with you in conversation using at least 2 back-and-forth exchanges ^e	3 y
Asks who, what, where, or why questions, like "Where is mommy/daddy?"	3 y
Says what action is happening in a picture when asked, like running, eating, or playing	3 y
Says first name when asked	3 y
Talks well enough for others to understand, most of the time	3 y



Cognitive Milestones	Age
Holds something in 1 hand while using the other hand, for example, holding a container and taking the lid off ^d	24 mo
Tries to use switches, knobs, or buttons on a toy	24 mo
Plays with >1 toy at the same time, like putting toy food on a toy plate	24 mo
Uses things to pretend, like feeding a block to a doll as if it were food	30 mo
Shows simple problem-solving skills, like standing on a small stool to reach something	30 mo
Follows 2-step instructions, for example, "Put the toy down and close the door."	30 mo
Shows that he knows at least 1 color, like pointing to a red crayon when you ask, "Which one is red?"	30 mo
Draws a circle when you show him how	3 y
Avoids touching hot objects, like a stove, when you warn her ^d	3 y

- Exists on a continuum
 - Persistent deficits in social communication and interaction
 - Repetitive patterns of behavior, interests and activities
- More complex cases diagnosed in early childhood. Milder cases may not be diagnosed until adulthood
- Masking features to blend – this may cause anxiety
- Intellectual disability may exist, but not the hallmark

Autism

- 15-25/1000
- Males 4x greater prevalence than females
- Siblings can have 20% prevalence

- Intellectual Delay in 50%
- ADHD in 30%
- 25% as part of clinically defined syndromes
 - Tuberous Sclerosis, Fragile X, Chromosomal Duplication syndromes, Angelman syndrome, Rett Syndrome, Syndromes of Macrocephaly, CHARGE Syndrome, Joubert Syndrome, Smith-Lemli-Opitz Syndrome and Timothy Syndrome

Autism – comorbid illness

- Seizures
- Lead poisoning
- Depression
- Anxiety
- Hyperactivity
- Sleep disturbances
- Feeding and nutritional issues
- Impairments of daily living

Autism – severity

Severity	Social communication / Interaction	Repetitive / Restricted behavior
Level 1: Requiring support (Mild)	Noticeable impairment without support – difficulty initiating social interactions, visible social isolation	Behaviors significantly interfere with function – difficulty in switching between behaviors, focus on special interests (trains), general topics or collecting
Level 2: Requiring substantial support (Moderate)	Marked deficits in communication – reduced responses to social cues	Behaviors sufficiently frequent and obvious to casual observer – substantial rigidity in changing focus or attention
Level 3: Requiring very substantial support (Severe)	Severe impairments in functioning – nonverbal or physical gesturing to communicate, presence of echolalia	Behaviors markedly interfere with function– rocking or spinning, flapping, sniffing, handling, mouthing

Autism – mortality

Table 3 Risk for all-cause mortality for the entire autism spectrum disorder (ASD) group, as well as separately for females and males, and low-functioning ASD and high-functioning ASD groups

	Controls	ASD OR (95% CI)	Low-functioning ASD OR (95% CI)	High-functioning ASD OR (95% CI)
	Number of deaths (%)	Number of deaths (%)	Number of deaths (%)	Number of deaths (%)
Total	24 358 (0.91)	2.56 (2.38–2.76) 706 (2.60)	5.78** (4.94–6.75) 169 (2.71)	2.18 (2.00–2.38) 537 (2.57)
Females	11 693 (1.39)	2.24 (1.99–2.51) 296 (3.51)	8.52 (6.55–11.08) 61 (3.00)	1.88 (1.65–2.14) 235 (3.67)
Males	12 665 (0.69)	2.87* (2.60–3.16) 410 (2.19)	4.88 (4.02–5.93) 108 (2.57)	2.49 (2.22–2.80) 302 (2.08)

ASD, autism spectrum disorder; OR, odds ratio; CI, confidence interval.

*Partial likelihood ratio test for interaction effect ASD × gender, $P = 0.001$.

**Partial likelihood ratio test for model selection (low-functioning ASD/high-functioning ASD), $P < 0.001$.

Autism – mortality

Table 4 Cause-specific mortality in relation to ASD and separately for low-functioning ASD and high-functioning ASD^a

	Controls, <i>n</i> of deaths (%)	ASD OR (95% CI) <i>n</i> of deaths (%)	Low-functioning ASD OR (95% CI), <i>n</i> of deaths (%)	High-functioning ASD OR (95% CI), <i>n</i> of deaths (%)
Infections	245 (0.01)	1.83 (0.75–4.30) 5 (0.02)	N/A	N/A
Neoplasms	4493 (0.17)	1.80 (1.46–2.23) 88 (0.32)	2.12 (1.25–3.61) 14 (0.22)	1.75 (1.39–2.21) 74 (0.35)
Endocrine	474 (0.02)	3.70 (2.34–5.87) 19 (0.07)	8.89 (3.52–22.41) 5 (0.08)	3.07 (1.80–5.23) 14 (0.07)
Mental and behavioural disorders	925 (0.03)	2.80 (1.94–4.03) 30 (0.11)	21.81** (12.20–39.00) 14 (0.22)	1.58 (0.96–2.59) 16 (0.08)
Nervous system	737 (0.03)	7.49 (5.78–9.72) 62 (0.23)	40.56** (26.82–61.33) 32 (0.51)	3.98 (2.76–5.74) 30 (0.14)
Circulatory system	8820 (0.33)	1.49 (1.27–1.75) 157 (0.58)	4.61** (3.06–6.95) 24 (0.38)	1.33 (1.12–1.58) 133 (0.64)
Respiratory system	1351 (0.05)	2.68 (1.99–3.62) 45 (0.17)	13.92** (7.04–27.50) 10 (0.16)	2.17 (1.55–3.05) 35 (0.17)
Digestive system	733 (0.03)	3.31 (2.25–4.87) 27 (0.10)	9.13* (4.42–18.87) 8 (0.13)	2.61 (1.65–4.12) 19 (0.09)
Genitourinary system	253 (0.01)	3.82 (2.13–6.84) 12 (0.04)	N/A	N/A
Congenital malformations	106 (<0.01)	19.10 (11.94–30.55) 21 (0.08)	38.75* (20.39–73.64) 13 (0.21)	10.38 (4.98–21.61) 8 (0.04)
Symptoms, signs and abnormal findings, other	618 (0.02)	1.81 (1.06–3.08) 14 (0.05)	N/A	N/A
Suicide	1094 (0.04)	7.55 (6.04–9.44) 83 (0.31)	2.41 (1.14–5.11) 7 (0.11)	9.40** (7.43–11.90) 76 (0.36)
External causes, other	1696 (0.06)	1.67 (1.16–2.40) 30 (0.11)	1.53 (0.69–3.44) 6 (0.10)	1.71 (1.14–2.56) 24 (0.11)
Other	232 (0.01)	5.84 (3.46–9.86) 15 (0.06)	N/A	N/A

ASD, autism spectrum disorder; OR, odds ratio; CI, confidence interval.
a. Missing data on primary cause of death (*n* = 2677, <0.5% in both groups); N/A analyses were not performed owing to the low number of cases in certain cells; partial likelihood ratio test for model selection (low-functioning ASD/high-functioning ASD).
P* < 0.01 (Digestive *P* = 0.009; Congenital malformations *P* = 0.007); *P* < 0.001.

Autism – mortality

- Adaptive social and communication strategies can improve mortality
- Suicide presents the greatest cause of mortality for high-functioning autistic patients
 - In both those with and without documented psychiatric illness
 - Social disengagement and greater insight; access
- Diseases are diagnosed late and in advanced presentation

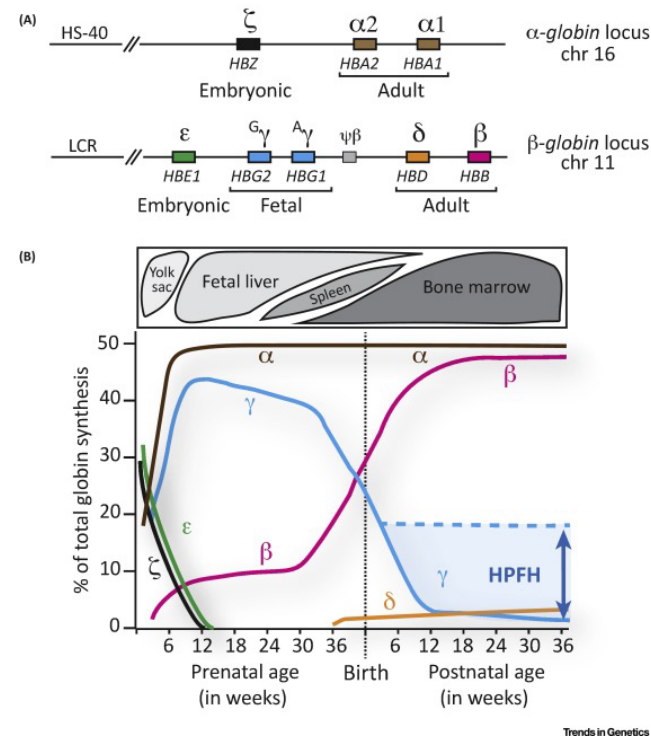
AND THEN THERE'S THE TESTS

Anemic

- 1 year old applicant with **one admission at 4 months with bronchiolitis**, very responsive to treatment.
- **Otherwise up to date with immunization.**
- **Normal Growth and Development.**
- While admitted there was a CBC done that showed a **hemoglobin of 10.5 g/dL.**
- They have a 1 year pediatric well visit in 1 month and will have a CBC done at that time, but the **agent is in a rush** to place the case.

Normal Hemoglobin Levels Chart

Age	Normal hemoglobin Level (g/dl)
Newborns	13.5 - 24
<1 month	10 - 20
1-2 months	10-18
0.5 to 2 years	10.5-13.5
2 to 6 years	11.5-13.5
6-12 years	11.5-15.5
Female: 12-18 years	12.0-16.0
Male: 12-18 years	13.0-16.0
Female: >18 years	12.1-15.1
Male: >18 years	13.6-17.7
Men after middle age	12.4-14.9
Women after middle age	11.7-13.8



The Same Applies to Other Lab Results (ALP – 44-147 IU/L)

TABLE I. Total serum alkaline phosphatase reference ranges for apparently healthy males and females of different age groups.

Age (yrs)	Males				Females			
	Mean	(No.)	SD	Ranges	Mean	(No.)	SD	Ranges
1-4	213	(17)	51	111-315	184	(18)	36	112-256
5-9	217	(111)	35	147-287	214	(82)	44	126-302
10-14	242	(124)	57	128-356	208	(87)	77	54-362
15-19	97	(34)	26	45-149	64	(28)	11	42-86
20-24	69	(22)	17	35-105	49	(20)	12	25-73
25-29	67	(16)	18	31-99	56	(24)	10	36-76
30-39	75	(26)	19	37-113	63	(31)	14	35-91
40-49	77	(24)	23	31-123	65	(40)	18	29-101
50-59	72	(26)	20	32-123	79	(25)	14	51-107
> 60	79	(18)	16	47-111	83	(13)	21	41-125

Pediatric Vital Signs



PEDIATRIC VITAL SIGNS REFERENCE CHART



Heart Rate (beats/min)			Respiratory Rate (breaths/min)	
Age	Awake	Asleep	Age	Normal
Neonate (<28 d)	100-205	90-160	Infant (<1 y)	30-53
Infant (1-12 mos)	100-190			
Toddler (1-2 y)	98-140	80-120	Toddler (1-2 y)	22-37
Preschool (3-5 y)	80-120	65-100	Preschool (3-5 y)	20-28
School-age (6-11 y)	75-118	58-90	School-age (6-11 y)	18-25
Adolescent (12-15 y)	60-100	50-90	Adolescent (12-15 y)	12-20
<i>Reference: PALS Guidelines, 2015</i>				
Blood Pressure (mmHg)				
Age		Systolic	Diastolic	Systolic Hypotension
Birth (12 h)	<1 kg	39-59	16-36	<40-50
	3 kg	60-76	31-45	<50
Neonate (96 h)		67-84	35-53	<60
Infant (1-12 mos)		72-104	37-56	<70
Toddler (1-2 y)		86-106	42-63	<70 + (age in years × 2)
Preschool (3-5 y)		89-112	46-72	
School-age (6-9 y)		97-115	57-76	
Preadolescent (10-11 y)		102-120	61-80	<90
Adolescent (12-15 y)		110-131	64-83	
<i>Reference: PALS Guidelines, 2015</i>				
<i>For diagnosis of hypertension, refer to the 2017 AAP guidelines Table 4 & 5: http://pediatrics.aappublications.org/content/early/2017/08/21/peds.2017-1904</i>				

Temperature (°C)		Oxygen Saturation (SpO ₂)
Method	Normal	
Rectal	36.6-38.0	SpO ₂ is lower in the immediate newborn period. Beyond this period, a SpO ₂ of <90-92% may suggest a respiratory condition or cyanotic heart disease .
Tympanic	35.8-38.0	
Oral	35.5-37.5	
Axillary	36.5-37.5	
Ranges do not vary with age. Screening: axillary, temporal, tympanic (↓ accuracy) Definitive: rectal & oral (↑ reflection of core temp.) <i>Reference: CPS Position Statement on Temperature Measurement in Pediatrics (2015)</i>		

Dr. Chris Novak & Dr. Peter Gill for www.pedscases.com
(Edited March 2020 by Richard He)

Pediatric Hypertension - Challenges

- Pediatric HTN prevalence is estimated at 4% in the United States and worldwide.
- 76% of pediatric HTN cases go undiagnosed and only 6% of patients who merit treatment receive it, leaving 1.5 million children in the US undiagnosed and untreated
- There is a well-established association between pediatric elevated blood pressure and adulthood cardiovascular disease (CVD).
- Adulthood CVD accounted for 21% of the deaths in the U.S. in 2020
- There is a higher prevalence of adult HTN and CVD in lower socioeconomic groups.
- Underdiagnosis in these groups can be amplified due to patient volumes and complexity of medical illness, both comorbid and non-comorbid.
- By 2030, 40.5% of the US population is projected to be diagnosed with CVD, with the total direct CVD medical costs alone expected to triple from \$273 billion to \$818 billion in that timespan.

Pediatric Hypertension - Challenges

To address these medical and social issues, we propose the development of a rule-based CDSS tool that will:

- Sit on top of a provider's EHR system.
- Screen pediatric patients and diagnose hypertension.
- Advise on HTN workups and treatments.
- Produce results independent of data cleanliness.

Benchmark Cases

To ensure the accuracy of our tool, 22 benchmark cases were created with a variety of patient profiles to help evaluate the various components of the tool. Along with the input patient information detailed below, the profiles include the expected diagnosis and treatment plan, supplemented with prevalence of elevated BP, the appropriate treatment steps, and the final HTN diagnosis.

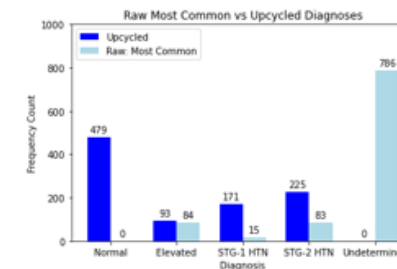
Parameter Name	Measurement Unit
Age	Years
Sex	M/F
Height	In.
Weight	Lbs.
BMI/BMI Assessment	Healthy/Overweight/Obese
Patient History	Yes/No
Pre-Existing Conditions	ICD-10 Codes
Previous HTN Diagnosis	Yes/No
Medications Present	Yes/No, RxNorm, Class
Blood Pressures (3)	SBP, DBP

Diagnosis Level	Patient Count
Congruent	12
Undiagnosed	1
More conservative by 1 stage	4
More aggressive by 1 stage	4
More aggressive by 2 stages	1

While 5 patients were over diagnosed, we are less concerned as the system will be used with human intervention and these patients will be evaluated by the clinician and receive the treatment they need. For the 4 underdiagnosed patients, all were 3-year-old females, which is a potential area for improvement in our system for future iterations.

Performance on Pre- and Post-Clinical Data Cleaning

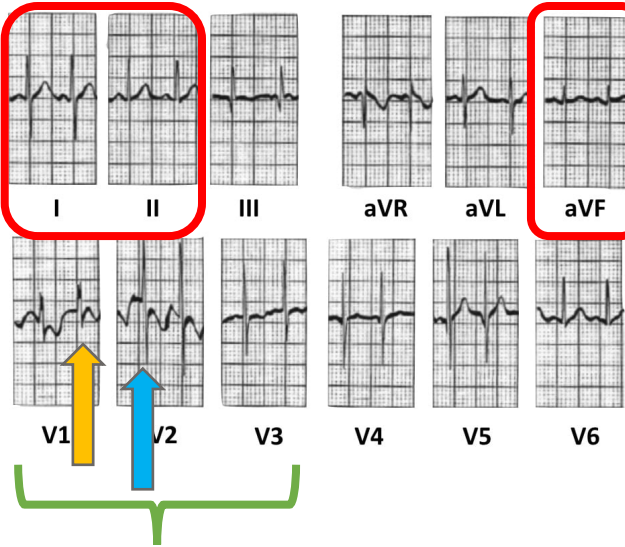
Lastly, we evaluated the system on multiple raw CCD and one normalized-longitudinal CCD per patient. The raw data lacked the ability to reliability diagnosis patients due to the lack of information.



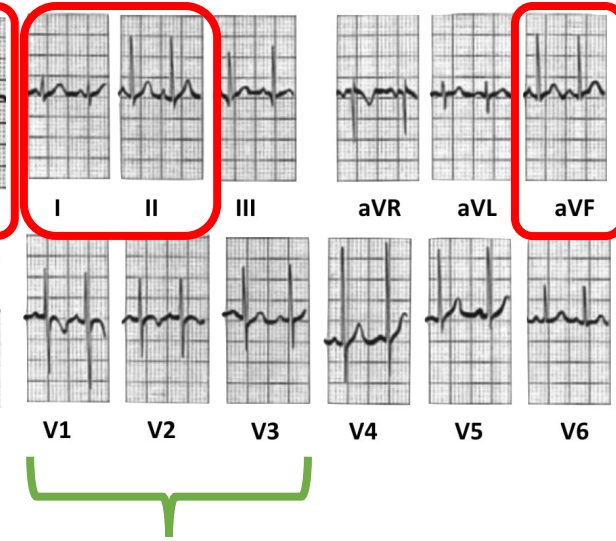
Out of all raw CCD diagnosis results, 46% came back undetermined and when considering just the most-common results per patient, as seen in the bar chart above, 81% came back undetermined.

Pediatric EKG Evolution

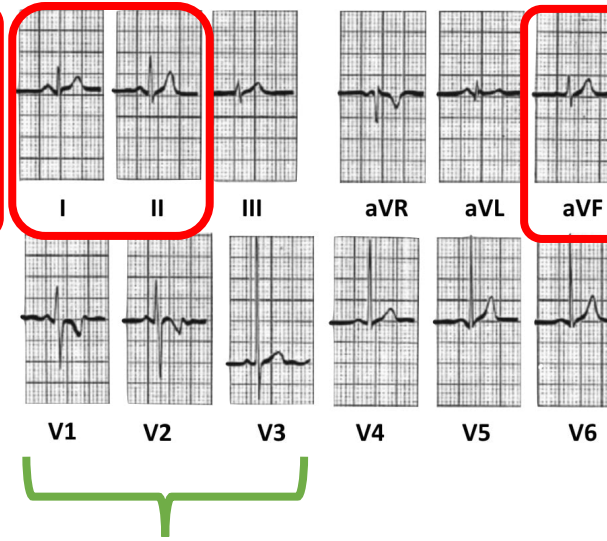
Normal ECG: Age 1 year



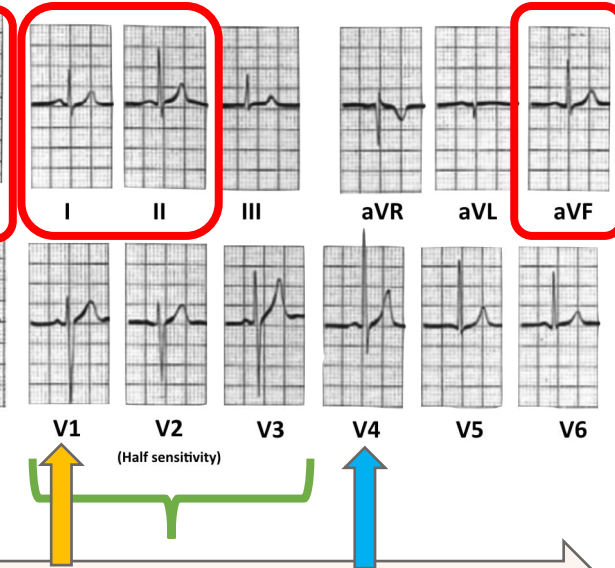
Normal ECG: Age 2 year



Normal ECG: Age 5 years



Normal ECG: Age 10 years



Heart Rate slows

Right Axis Deviation normalizes

T wave Inversion in V1-3 normalizes

Dominant R wave in V1 blunts

QRS widens

NORMAL WELL CARE - VACCINATION & SCREENING

Pediatric Vaccination Schedule – Birth to 18 years

Birth to 15 Months

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos
Hepatitis B Ⓞ (HepB)	1 st dose	→2 nd dose→			→3 rd dose→			
Rotavirus Ⓞ (RV) RV1 (2-dose series); RV5 (3-dose series)			1 st dose	2 nd dose	See notes			
Diphtheria, tetanus, & acellular pertussis Ⓞ (DTaP: <7 yrs)			1 st dose	2 nd dose	3 rd dose			→4 th dose→
Haemophilus influenzae type b Ⓞ (Hib)			1 st dose	2 nd dose	See notes			→3 rd or 4 th dose, See notes →
Pneumococcal conjugate Ⓞ (PCV13, PCV15)			1 st dose	2 nd dose	3 rd dose			→4 th dose→
Inactivated poliovirus Ⓞ (IPV: <18 yrs)			1 st dose	2 nd dose	→3 rd dose→			
COVID-19 Ⓞ (1vCOV-mRNA, 2vCOV-mRNA, 1vCOV-aPS)					2- or 3-dose primary series and booster (See notes)			
Influenza (IV4) Ⓞ					Annual vaccination 1 or 2 doses			
Influenza (LAIV4) Ⓞ								
Measles, mumps, rubella Ⓞ (MMR)					See notes			→1 st dose→
Varicella Ⓞ (VAR)								→1 st dose→
Hepatitis A Ⓞ (HepA)					See notes			→2-dose series, See notes →
Tetanus, diphtheria, & acellular pertussis Ⓞ (Tdap: ≥7 yrs)								
Human papillomavirus Ⓞ (HPV)								
Meningococcal Ⓞ (MenACWY-D: ≥9 mos, MenACWY-CRM: ≥2 mos, MenACWY-TT: ≥2years)					See notes			
Meningococcal B Ⓞ (MenB-4C, MenB-FHbp)								
Pneumococcal polysaccharide Ⓞ (PPSV23)								
Dengue Ⓞ (DEN4CYD: 9-16 yrs)								

18 Months to 18 Years

Vaccines	18 mos	19-23 mos	2-3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13-15 yrs	16 yrs	17-18 yrs
Hepatitis B Ⓞ (HepB)	→3 rd dose→								
Rotavirus Ⓞ (RV) RV1 (2-dose series); RV5 (3-dose series)									
Diphtheria, tetanus, & acellular pertussis Ⓞ (DTaP: <7 yrs)	→4 th dose→			5 th dose					
Haemophilus influenzae type b Ⓞ (Hib)									
Pneumococcal conjugate Ⓞ (PCV13, PCV15)									
Inactivated poliovirus Ⓞ (IPV: <18 yrs)	→2 nd dose→			4 th dose					See notes
COVID-19 Ⓞ (1vCOV-mRNA, 2vCOV-mRNA, 1vCOV-aPS)	2- or 3- dose primary series and booster (See notes)								
Influenza (IV4) Ⓞ	Annual vaccination 1 or 2 doses					Annual vaccination 1 dose only			
Influenza (LAIV4) Ⓞ	Annual vaccination 1 or 2 doses					Annual vaccination 1 dose only			
Measles, mumps, rubella Ⓞ (MMR)				2 nd dose					
Varicella Ⓞ (VAR)				2 nd dose					
Hepatitis A Ⓞ (HepA)	→2-dose series, See notes →								
Tetanus, diphtheria, & acellular pertussis Ⓞ (Tdap: ≥7 yrs)						1 dose			
Human papillomavirus Ⓞ (HPV)						See notes			
Meningococcal Ⓞ (MenACWY-D: ≥9 mos, MenACWY-CRM: ≥2 mos, MenACWY-TT: ≥2years)	See notes					1 st dose		2 nd dose	
Meningococcal B Ⓞ (MenB-4C, MenB-FHbp)						See notes			
Pneumococcal polysaccharide Ⓞ (PPSV23)						See notes			
Dengue Ⓞ (DEN4CYD: 9-16 yrs)						Seropositive in endemic dengue areas (See notes)			

Pediatric Screening Schedule – Prenatal to 21 years

AGE ¹	INFANCY								EARLY CHILDHOOD						MIDDLE CHILDHOOD						ADOLESCENCE														
	Prenatal ²	Newborn ³	3-5 d ⁴	By 1 mo	2 mo	4 mo	6 mo	9 mo	12 mo	15 mo	18 mo	24 mo	30 mo	3y	4y	5y	6y	7y	8y	9y	10y	11y	12y	13y	14y	15y	16y	17y	18y	19y	20y	21y			
HISTORY Initial/Interval	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
MEASUREMENTS																																			
Length/Height and Weight		●	●	●	●	●	●	●	●	●	●	●	●	●	●																				
Head Circumference		●	●	●	●	●	●	●	●	●	●	●	●	●	●																				
Weight for Length		●	●	●	●	●	●	●	●	●	●	●	●	●	●																				
Body Mass Index ⁵																●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Blood Pressure ⁶		★	★	★	★	★	★	★	★	★	★	★	★	★	★	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
SENSORY SCREENING																																			
Vision ⁷		★	★	★	★	★	★	★	★	★	★	★	★	★	●	●	★	●	★	●	●	●	★	●	★	★	●	★	★	★	★	★	★	★	
Hearing		● ⁸	● ⁹	→	→	★	★	★	★	★	★	★	★	★	●	●	★	●	★	●	●	●	←	←	● ¹⁰	→	←	←	→	→	→	→	→		
DEVELOPMENTAL/SOCIAL/BEHAVIORAL/MENTAL HEALTH																																			
Maternal Depression Screening ¹¹				●	●	●	●																												
Developmental Screening ¹²								●			●	●																							
Autism Spectrum Disorder Screening ¹³										●	●																								
Developmental Surveillance		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Behavioral/Social/Emotional Screening ¹⁴		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Tobacco, Alcohol, or Drug Use Assessment ¹⁵																							★	★	★	★	★	★	★	★	★	★	★	★	
Depression and Suicide Risk Screening ¹⁶																							★	★	★	★	★	★	★	★	★	★	★	★	
PHYSICAL EXAMINATION¹⁷		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
PROCEDURES¹⁸																																			
Newborn Blood		● ¹⁹	● ²⁰	→																															
Newborn Bilirubin ²¹		●																																	
Critical Congenital Heart Defect ²²		●																																	
Immunization ²³		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Anemia ²⁴					★				●	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	
Lead ²⁵						★	★	● or ★ ²⁶		★	● or ★ ²⁶		★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	
Tuberculosis ²⁷			★			★			★		★		★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	
Dyslipidemia ²⁸											★			★		★		★		★		★		★		★		★		★		★		★	
Sexually Transmitted Infections ²⁹																							★	★	★	★	★	★	★	★	★	★	★	★	
HIV ³⁰																							★	★	★	★									
Hepatitis B Virus Infection ³¹		★																																	
Hepatitis C Virus Infection ³²																																			
Sudden Cardiac Arrest/Death ³³																							★												
Cervical Dysplasia ³⁴																																			
ORAL HEALTH³⁵																																			
Fluoride Varnish ³⁷							←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	←	
Fluoride Supplementation ³⁸							★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
ANTICIPATORY GUIDANCE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	

MALIGNANCY KEPT SHOWING UP,
SO . . .

Malignancy kept showing up so . . .

- 10,500 children ages 0 to 14 years diagnosed annually with cancer
- 1,190 die of the disease (2021)
- Adolescents (15 to 19 years) ~ 5,090 will diagnosed with, 590 will die of the disease
- Most common types of cancer among children and adolescents in the United States are leukemias and lymphomas, brain and central nervous system tumors
- Incidence increasing at 0.8% per year since 1975
- More than 80% of children with cancer are cured

Most Frequent Types of Cancer in U.S. Children and Adolescents*

Type of Cancer	Children Birth to 14 years (approximate percentage of cases)	Adolescents 15-19 years (approximate percentage of cases)
Lymphoid leukemia (acute and chronic)	22%	7%
Acute myeloid leukemia	4%	4%
Hodgkin lymphoma	3%	12%
Non-Hodgkin lymphoma	5%	7%
Brain and other central nervous system cancer	26%	21%
Neuroblastoma & other peripheral nerve tumors	6%	<1%
Nephroblastoma & other nonepithelial renal (kidney) tumors, including Wilms' tumor	5%	<1%
Hepatic (liver) tumors	2%	<1%
Osteosarcoma	2%	3%
Ewing tumor and related bone sarcomas	1%	2%
Rhabdomyosarcoma	3%	<1%
Germ cell & gonadal tumors	3%	11%
Thyroid carcinoma	2%	11%
Malignant melanoma (skin cancer)	1%	4%
Other types of cancer (not listed above)	15%	16%

*as reported from 2011-2015

Source: Cancer Statistics, 2019 CA: A Cancer Journal for Clinicians/ Volume 69, Issue 1

THANK YOU