Annual Report

Newborn Screening 2014

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Executive Summary

In 2014 there were 87,415 infants born in Washington (an additional 1,013 were born at two military facilities in our state that do not participate in this program). The Department of Health's Newborn Screening (NBS) Program tested these infants for 28 treatable, but potentially deadly or disabling, disorders that the Washington State Board of Health has specified in chapter 246-650 Washington Administrative Code (WAC). Among these infants, 97 were affected with a severe form of one of the disorders and were quickly referred to appropriate preventive care systems before they suffered irreversible damage from their conditions[1].

In addition, 107 infants were identified with a condition that required treatment or close monitoring[2], and 1,339 infants were identified with abnormalities of hemoglobin that, while not directly harmful, can have important implications for future reproductive choices for the infants and their parents. In these cases, the infants' healthcare providers were notified of the findings and their implications, and were provided a list of resources to help families understand how the findings might impact them.

The department's cost to operate the program—including follow-up, education and evaluation, as well as the laboratory testing—is covered through a fee charged for each infant through the hospital of birth. In 2014 this charge was $69 for each child. This modest investment is typically covered by insurance and other third-party payers. In return, the state's healthcare system realizes significant savings by avoiding the costs of lifetime treatment for disabling conditions.

The report includes a series of appendixes which document newborn screening efforts in Washington State over time and give specific details about the complexities of hemoglobin screening.

[1] This number excludes one infant who expired shortly after birth (day of life three) before the newborn screening specimen could be tested.

[2] This number includes mild forms of the disorders on the required newborn screening panel and a small number of non-panel conditions identified through the screening process.

Introduction

This report is presented in accordance with Washington Administrative Code (WAC) 246-650-040, which requires an annual report of information on newborn screening to the Board of Health. Information on newborn screening during 2014 is presented in the attached series of tables and accompanying explanations. Data relating to all births were extracted from 2014 birth certificates by the department's Center for Health Statistics. These data relate to live-birth occurrences within the state. Data relating to infants detected, infants screened, and costs were extracted from data routinely maintained by the department.

The data exclude information relating to infants born at Oak Harbor Naval Hospital and Bremerton Naval Hospital in 2014. These military hospitals did not participate in Washington's Newborn Screening Program during this time.

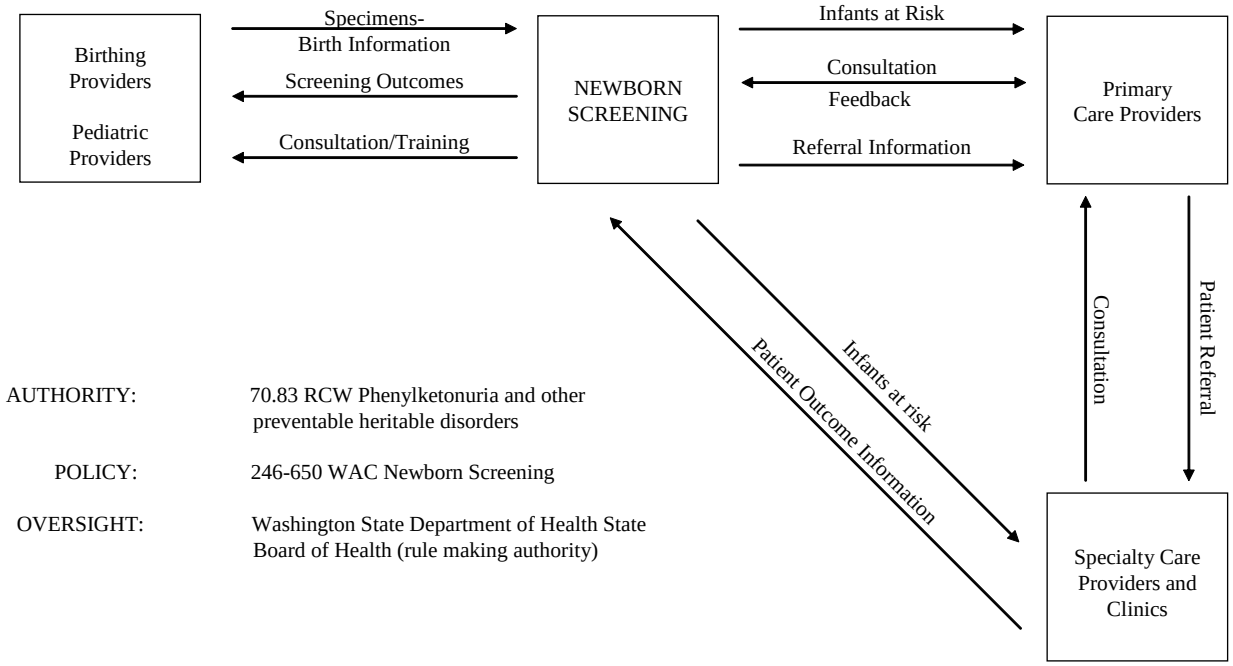
Newborn Screening Schematic Overview

NEWBORN SCREENING

CORE FUNCTION: PREVENTION of severe physical disability or death

METHOD: POPULATION BASED SCREENING of all newborns carefully coordinated with providers of birthing, primary, and specialty care service

FOCUS: PREVENTABLE DISEASE that would go undetected without this screening and result in catastrophic outcomes



AUTHORITY: 70.83 RCW Phenylketonuria and other preventable heritable disorders

POLICY: 246-650 WAC Newborn Screening

OVERSIGHT: Washington State Department of Health State Board of Health (rule making authority)

The Newborn Screening Program also strives to assure families' involvement in this system through their primary care providers and, for affected infants, through the specialty care providers and clinics.

Disorders Detected and Abbreviations Used

Following is a brief description of each of the disorders identified through the Newborn Screening Program and abbreviations that are used throughout the report.

AA **Amino acid disorders:** disorders of metabolism characterized by the body's inability to correctly process amino acids or the inability to process the ammonia that is released during the breakdown of amino acids. The accumulation of amino acids, ammonia or other by-products may cause severe complications including intellectual disabilities, coma, seizures, and possibly death. Early detection and treatment can prevent most or all of these consequences. Disorders are:

- Argininosuccinic acidemia (ASA)
- Citrullinemia (CIT)
- Homocystinuria (HCY)
- Maple Syrup Urine Disease (MSUD)
- Phenylketonuria (PKU)
- Tyrosinemia type I (TYR I)

BIO **Biotinidase deficiency:** deficiency of the enzyme that affects normal recycling of biotin, one of the B vitamins. If untreated, a severe deficiency of biotin can result in metabolic crisis, coma and death. Treatment with biotin can prevent all symptoms.

CAH **Congenital adrenal hyperplasia:** excessive production of androgenic hormones due to a defect in the pathway that converts cholesterol into the hormone cortisol. The most common defect, and the primary target of our screening, is deficiency of the enzyme 21-hydroxylase. Deficiency of this enzyme accounts for approximately 95 percent of all cases of CAH. If untreated, CAH can lead to an imbalance in the body's concentration of salts which in turn can rapidly lead to shock and death. It also causes excessive masculinization and extremely premature sexual maturation. Treatment consists of providing cortisol which normalizes hormone production. Proper treatment prevents death and stops the masculinization process. Affected females may require surgical correction of masculinized genitalia.

CH **Congenital hypothyroidism:** insufficient production of the thyroid hormone thyroxine due to malformation or malfunction of the thyroid gland. If untreated, CH can result in severe neurological and developmental damage. Treatment consists of hormone replacement with synthetic thyroxine. Affected infants develop normally with proper treatment.

CF **Cystic fibrosis:** defect in the cystic fibrosis transmembrane conductance regulator (CFTR) gene which regulates the body's salt and water secretions. This results in the build-up of thick, sticky mucus in the lungs and digestive system. Treatment consists of pancreatic enzymes, vitamin supplements, chest physiotherapy, and antibiotics. Early treatment improves physical growth, cognitive function and lung function.

Disorders Detected and Abbreviations Used (continued)

FAO **Fatty acid oxidation disorders:** disorders of metabolism characterized by the inability to efficiently use fat to make energy. During times of extra energy need, such as prolonged fasting or acute illness, affected infants can suffer dangerously low blood sugar and metabolic crises resulting in serious damage affecting the brain, liver, heart, eyes and muscles, and possibly death. Early detection and treatment can prevent most or all of these consequences. Disorders are:

- Carnitine uptake deficiency.
- Long-chain L-3-OH acyl-CoA dehydrogenase (LCHAD) deficiency.
- Medium chain acyl-CoA dehydrogenase (MCAD) deficiency.
- Trifunctional protein (TFP) deficiency.
- Very long-chain acyl-CoA dehydrogenase (VLCAD) deficiency.

GAL **Galactosemia:** deficiency in one of three enzymes that help convert galactose into glucose. Our screening targets the most common, classic form of the disorder. If untreated, an affected baby may develop jaundice, vomiting, lethargy, hepatosplenomegaly, cataracts and failure to thrive. Also, the condition can lead to liver failure, sepsis and death. A galactose-free diet with strict avoidance of lactose (milk sugar) and lactose-containing foods prevents death, and assists growth and development.

HB **Hemoglobinopathies:**

SCD **Sickle cell disease:** a condition marked by a tendency for the blood cells to take on a sickle shape due to an abnormal structure of the hemoglobin molecule. The altered shape results in anemia due to shortened life span of the blood cells and impedes circulation, especially in capillaries. Children with sickle cell disease are highly susceptible to bacterial infections and rapid pooling of blood in their spleens. Either can rapidly lead to death. Treatment consists of regular doses of penicillin to prevent infection and training parents to recognize splenic crisis. Proper treatment dramatically reduces infections and death.

Other **Significant hemoglobinopathies:** hemoglobin abnormalities, other than sickle cell disease, that have significant clinical consequences (for example, transfusion dependent thalassemia). These conditions generally don't require immediate treatment, but early identification allows families to adjust to the diagnosis, anticipate the medical needs, and begin early treatment plans as necessary.

Disorders Detected and Abbreviations Used (continued)

OA **Organic acid disorders:** disorders of metabolism characterized by the accumulation of non-amino organic acids and toxic intermediates. This may lead to metabolic crisis with increases in acid and ammonia in the blood, and dangerously low blood sugar resulting in severe nerve and physical damage and possibly death. Early detection and treatment can prevent most or all of these consequences. Disorders are:

- 3-OH 3-CH3 glutaric aciduria (HMG).
- Beta-ketothiolase deficiency (BKT).
- Isovaleric acidemia (IVA).
- Methylmalonic acidemia (Cbl A, B).
- Methylmalonic acidemia (mutase deficiency) (MUT).
- Multiple carboxylase deficiency (MCD).
- Propionic acidemia (PROP).

SCID **Severe combined immunodeficiency:** a group of disorders of immune system development characterized by absent or low T-cell counts. Babies with SCID are at risk for developing life-threatening infections within the first year of life. Early detection and treatment allow for curative bone-marrow transplant in the first months of life.

Table I: Births by County of Occurrence
Infants Detected by County of Residence

County	2014 Births	2014 Infants Detected										All Infants
		AA	BIO	CAH	CH	CF	FAO	GAL	HB	OA	SCID	
Adams	479	-	-	-	-	-	-	-	-	1	-	1
Asotin	1	-	-	-	-	-	-	-	-	-	-	0
Benton	4,598	1	-	-	5	-	1	-	1	-	-	8
Chelan	1,546	-	-	-	-	-	-	-	-	-	1	1
Clallam	620	-	-	-	-	-	-	-	-	-	-	0
Clark	5,527	-	-	-	4	-	1	3	-	-	-	8
Columbia	0	-	-	-	-	-	-	-	-	-	-	0
Cowlitz	912	1	-	1	-	-	-	-	-	-	-	2
Douglas	3	-	-	1	-	1	-	-	-	-	-	2
Ferry	1	-	-	-	-	-	-	-	-	-	-	0
Franklin	36	-	-	1	4	-	-	-	-	-	-	5
Garfield	0	-	-	-	-	-	-	-	-	-	-	0
Grant	1,109	-	-	-	5	-	1	-	-	-	-	6
Grays Harbor	552	-	-	-	2	-	-	-	-	-	-	2
Island[a]	251	1	-	-	-	1	-	-	-	-	-	2
Jefferson	133	-	-	-	-	-	-	-	-	-	-	0
King	29,957	1	1	1	50	3	2	5	13	2	4	82
Kitsap[a]	2,015	-	-	-	-	-	-	-	2	-	-	2
Kittitas	343	-	-	-	-	-	-	1	-	-	-	1
Klickitat	27	-	-	-	-	-	-	-	-	-	-	0
Lewis	737	-	-	-	-	-	-	-	-	-	-	0
Lincoln	9	-	-	-	-	-	-	-	-	-	-	0
Mason	253	-	-	-	-	-	-	-	-	-	-	0
Okanogan	424	1	-	-	-	-	-	-	-	-	-	1
Pacific	6	-	-	-	-	-	-	-	-	-	-	0
Pend Oreille	84	-	-	-	-	-	2	-	-	-	-	2
Pierce	12,152	1	-	-	12	3	2	2	4	2	1	27
San Juan	5	-	-	-	-	-	-	-	-	-	-	0
Skagit	1,681	-	-	-	1	-	-	-	1	-	-	2
Skamania	4	-	-	-	-	-	-	-	-	-	-	0
Snohomish	6,257	-	-	-	16	1	-	1	4	-	1	23
Spokane	6,828	-	-	-	5	5	-	1	-	1	1	13
Stevens	310	-	-	-	2	-	1	-	-	-	-	3
Thurston	3,027	-	-	1	2	-	-	-	1	-	-	4
Wahkiakum	1	-	-	-	-	-	-	-	-	-	-	0
Walla Walla	818	-	-	-	1	-	-	-	-	-	-	1
Whatcom	2,202	-	-	-	1	-	-	-	-	-	1	2
Whitman	478	-	-	-	-	-	-	-	-	-	-	0
Yakima	4,029	-	-	-	3	-	1	-	-	-	1	5
Total[a]	87,415	6	1	5	113	14	11	13	26	6	10	205

[a] Excludes infants born in military hospitals that do not participate in the Newborn Screening Program (287 born at Oak Harbor Naval Hospital and 726 born at Bremerton Naval Hospital). Total excluded =1,013.

Table II: Births and Infants Detected by Infant's Race

Infants Race[a]	2014 Births	2014 Infants Detected[a]										All Infants
		AA	BIO	CAH	CH	CF	FAO	GAL	HB	OA	SCID	
White	62,816	5	-	3	46	13	8	9	-	3	6	**93**
African American	3,371	-	1	-	1	-	-	2	12	1	-	**17**
Asian	5,911	-	-	-	16	-	-	-	6	-	1	**23**
Native American	976	-	-	-	2	-	-	-	-	-	-	**2**
Other[b]	13,017	1	-	1	36	-	3	2	6	1	2	**52**
Unknown[c]	1,324	-	-	1	12	1	-	-	2	1	1	**18**
Total[d]	87,415	6	1	5	113	14	11	13	26	6	10	205
Hispanic[e]	19,611	2	-	3	22	1	1	-	3	2	1	**35**

[a] The infant's race for 2014 is from birth certificate data and was determined by an algorithm of mother and father's race developed by the National Center for Health Statistics. The race of infants detected is from information provided on the newborn screening test form.

[b] Reflects other races not listed above (including Pacific Islander) and multiracial (more than one race designation on the screening form or birth certificate).

[c] Race was not reported on the screening form.

[d] Excludes infants born in military hospitals that do not participate in the Newborn Screening Program (287 born at Oak Harbor Naval Hospital and 726 born at Bremerton Naval Hospital). Total excluded =1,013.

[e] Hispanics can be of any race; they are included in the figures above.

Newborn Screening Follow-Up Procedures

All specimens determined to be presumptive positive through the Newborn Screening Program are followed up immediately through direct telephone contact with the child's physician. This is to ensure that diagnostic testing and treatment, if indicated, begins as quickly as possible. Following a definitive diagnosis, a long-term, disease-specific medical management program is implemented as follows:

Phenylketonuria (PKU) - Children are seen monthly in Seattle and every other month in Spokane by the Department of Health (DOH)-subsidized University of Washington Phenylketonuria Clinic. An interdisciplinary team consisting of a pediatric metabolic physician, nutritionists, social worker, and genetic counselor work closely with each family to optimize the child's dietary compliance through intensive education and support services. Periodic neuropsychological assessments are also provided for all patients to monitor cognitive and emotional development. For adults with PKU, consultative, support and nutritionist management services are provided at the University of Washington Division of Metabolism and Nutrition. Critical reproductive counseling and maternity services for women at risk of fetal damage due to Maternal PKU are also available. Other program components include a summer camp and Science Night through the private, nonprofit PKU Action Group.

Galactosemia, biotinidase deficiency, amino acid, organic acid and fatty acid oxidation disorders - All children with these disorders are seen periodically as needed by the DOH-subsidized University of Washington or Seattle Children's Biochemical Genetics Clinics in Seattle, or Mary Bridge Children's Hospital in Tacoma. There are quarterly satellite clinics held in Spokane. As with PKU, an interdisciplinary team consisting of a pediatric metabolic physician, nurses, nutritionists and a genetic counselor work closely with each family to optimize the child's compliance with the specific treatment plan through intensive education and support services.

Congenital hypothyroidism (CH) - Thyroid hormone therapy is monitored by the child's primary healthcare provider and/or pediatric endocrinologist. The DOH-subsidized Congenital Hypothyroidism Developmental Evaluation Clinic at the University of Washington provides developmental, neuropsychological and occupational therapy assessments for affected children.

Congenital adrenal hyperplasia (CAH) - All children are seen for a diagnostic work-up by a pediatric endocrinologist to establish appropriate steroid hormone therapy. Long-term management is monitored by the child's primary healthcare provider and/or pediatric endocrinologist. Affected females with genital abnormalities related to the disorder are referred for surgical consultation.

Cystic fibrosis (CF) - All children with cystic fibrosis are seen periodically as needed by one of the four regional CF Foundation accredited clinics – Children's Hospital (Seattle), Mary Bridge (Tacoma), Deaconess Hospital (Spokane), or Oregon Health Sciences University (Portland). As

with PKU, an interdisciplinary team consisting of a pediatric pulmonologist, nutritionist, social worker, and nurse work closely with each family to optimize the child's growth and minimize medical complications of the condition, particularly lung disease.

Sickle cell disease and other clinically significant hemoglobinopathies (HB) - Affected children receive prophylactic penicillin and folic acid. Long-term management is provided by a pediatric hematologist or an interdisciplinary team consisting of a pediatric hematologist, nurse, social worker and genetic counselor at a DOH-subsidized Comprehensive Sickle Cell Clinic – Children's Hospital Odessa Brown Center (Seattle) or Mary Bridge Children's Center (Tacoma). The clinic staff works closely with each family to optimize the child's health and well-being through intensive education and support services. Periodic assessments are also provided for all patients to monitor cognitive and emotional development. Other sickle cell disease program components include a summer camp and other educational and support activities through the DOH-supported Northwest Sickle Cell Collaborative.

Severe combined immunodeficiency (SCID) - Affected children receive immediate clinical care by immunologists at Seattle Children's Hospital. Caregivers take preventive measures to avoid exposing the baby to infectious agents while a bone marrow donor is identified (best if there is a sibling match). Transplants are typically performed at two to three months of age at the Fred Hutchinson Cancer Research Center in Seattle. The babies are closely followed for one to two years by the immunologists following transplant to ensure that the transplant was successful in establishing a functional immune system.

Table III: Follow-Up Status of Infants Detected (Severe Disease)

Follow-Up	2014 Infants Detected										All Infants
	AA	BIO	CAH	CH	CF	FAO	GAL	HB*	OA	SCID	
Referred to medical specialist – (i.e., pediatric endocrinologist, hematologist, or comprehensive clinic)	5	0	5	47	12	7	1	11	3	1	92
Followed by primary care provider, with some consultation from specialist	0	0	0	1	1	0	0	0	0	0	2
Expired or Lost to Follow-up	0	0	0	1[a]	1[a]	1[b]	1[c]	0	0	0	4
Total	5	0	5	49	14	8	1	11	3	1	98

*See appendix A for severe hemoglobin diseases.

[a] Infant expired; death was not a result of the condition detected.

[b] Infant expired at ~~3~~three days of age prior to diagnosis and treatment.

[c] Family moved out of the country after diagnosis; some genetic counseling was received.

Table IV: Age at which Treatment Began for Infants Detected (Severe Disease)

Disorder	Number of Infants	Age Treatment Began (days)	
		Average	Range
AA	5	7	5 – 9
BIO	0	n/a	n/a
CAH	4[a]	7	4 – 11
CH	49	14	3 – 45
CF	13[b]	30	9 – 86
FAO	6[c]	6	4 – 8
GAL	2*	7	5 – 8
HB	9[d]	17	11 – 32
OA	3[e]	23	11 – 34
SCID	1	7	n/a
Total	91	15	3 – 86

[a] Excludes one infant that was diagnosed prenatally.

[b] Excludes one infant who expired before receiving treatment.

[c] Excludes two infants treated shortly after birth due to known older affected sibling .

*Includes one infant where treatment was delayed due to delayed transit of the specimen.

[d] Excludes one infant with a hemoglobin disease that does not require immediate treatment and one infant with Sickle Cell disease where treatment date is unknown.

[e] Excludes one infant treated shortly after birth due to a known older affected sibling.

Screening Costs 2014

The department's cost to operate the program—including laboratory testing, monitoring to assure adequate screening for all infants, follow-up of all abnormal findings, education and evaluation—is covered by a fee charged for each infant through the facility of birth. For the period covered, the charge was $69 for each child.

In addition to the screening fee, a separate charge of $8.40 per birth was collected during this period to support specialty clinic care for infants diagnosed through newborn screening.

APPENDIX A: Newborn Hemoglobin Screening – Explanation and Definitions of Phenotypes Found

Hemoglobins are perhaps the most complex of the conditions detected by newborn screening. More than a dozen genes are involved in hemoglobin production, and over 700 abnormalities have been described by researchers and clinicians. Also, a variety of combinations are possible for any individual. Many of the abnormalities are rare and most have no clinical implications. A primary objective of our program is to identify those infants with sickle cell disease because these infants will suffer far less illness and death if they are promptly entered into a comprehensive healthcare program that includes prophylactic treatment with penicillin.

PHENOTYPE	MOST LIKELY GENOTYPE/CLINICAL IMPLICATIONS
FSS	Homozygous for hemoglobin S. Results in sickle cell anemia, a severe form of sickle cell disease.
FSS + Bart's	Homozygous for hemoglobin S in combination with α-thalassemia[b]. Results in sickle cell anemia, a severe form of sickle cell disease.
FS–	Hemoglobin S in combination with β-thalassemia[a] major. A severe form of sickle cell disease.
FSC	Hemoglobin S in combination with hemoglobin C. Results in sickle C disease, a moderate to severe form of sickle cell disease.
F-Only	β-thalassemia[a] major. A severe hemolytic anemia requiring regular blood transfusions.
F-beta+	β-thalassemia[a] intermedia. Ranges from mild to moderate hemolytic anemia and may require blood transfusions.
FE–	Hemoglobin E in combination with β-thalassemia[a] major. A moderate to severe hemolytic anemia.
FSA	Hemoglobin S in combination with β-thalassemia[a] intermedia. A moderate to severe hemolytic anemia.
FSE	Hemoglobin S in combination with hemoglobin E. Results in sickle E disease, a moderate form of sickle cell disease.
FSD	Hemoglobin S in combination with hemoglobin D. Results in sickle D disease, a moderate form of sickle cell disease.
FSV	Hemoglobin S in combination with unknown variant hemoglobin. Depending on the unknown variant may result in a mild to moderate sickle cell disease.
FEA	Hemoglobin E in combination with β-thalassemia[a] intermedia. A mild to moderate hemolytic anemia.
FAA + CS + High Bart's	High level of hemoglobin Bart's indicative of multiple α-thalassemia[b] genes. Likelihood of Hemoglobin H/Constant spring disease, a moderate to severe hemolytic anemia.
FAA + High Bart's	High level of hemoglobin Bart's indicative of multiple α-thalassemia[b] genes. Likelihood of Hemoglobin H disease, a moderate to severe hemolytic anemia.
FAE + CS + High Bart's	Hemoglobin E trait with combination with two hemoglobins (Constant Spring and Bart's) indicative of multiple α-thalassemia[b] genes. Likelihood of Hemoglobin H/Constant Spring disease, a moderate to severe hemolytic anemia (might be somewhat ameliorated by presence of hemoglobin E).

[a] Decreased production of β globin chains; benign to severe anemia. Significant interaction with other β chain variants such as hemoglobin S, E, and D.

[b] Decreased production of α globin chains; benign to severe anemia depending on how many of the four α globin genes are affected.

Appendix A (continued)

PHENOTYPE	MOST LIKELY GENOTYPE/CLINICAL IMPLICATIONS
FAE + High Bart's	Hemoglobin E in combination with high level of hemoglobin Bart's indicative of multiple α-thalassemia[b] genes. Likelihood of Hemoglobin H disease, a moderate to severe hemolytic anemia (might be somewhat ameliorated by presence of hemoglobin E).
FCA	Hemoglobin C in combination with β-thalassemia[a] minor. A mild to moderate hemolytic anemia.
FCC	Homozygous for hemoglobin C. A mild to moderate hemolytic anemia.
FDD	Homozygous for hemoglobin D. A mild to moderate hemolytic anemia.
FEE	Homozygous for hemoglobin E. Mild anemia.
FEE + Bart's	Homozygous hemoglobin E in combination with α-thalassemia[b]. Mild anemia.
FA + CS + Bart's	Two hemoglobins (Constant Spring and Bart's) indicative of α-thalassemia[b] genes. Mild anemia.
FAE + CS + Bart's	Hemoglobin E trait in combination with two hemoglobins (Constant Spring and Bart's) indicative of α-thalassemia[b] genes. Mild anemia.
FAS + Bart's	Hemoglobin S trait in combination with α-thalassemia[b]. No clinical implications for S trait (see FAS, below). Benign to mild anemia.
FAC + Bart's	Hemoglobin C trait in combination with α-thalassemia[b]. No clinical implications for C trait (see FAC, below). Benign to mild anemia.
FAE + Bart's	Hemoglobin E trait in combination with α-thalassemia[b]. No clinical implications for E trait (see FAE, below). Benign to mild anemia.
FAA + Bart's	α-thalassemia[b]. Benign to mild anemia.
FA + Var + Bart's	An unidentified hemoglobin variant trait and α-thalassemia[b]. Benign to mild anemia.
FAS + Var	Hemoglobin S and unidentified variant trait. No clinical implications for S trait; clinical effects from variant trait unlikely. Family may be at risk for sickle cell disease.
FAC + Var	Hemoglobin C and unidentified variant trait. No clinical implications for C trait; clinical effects from variant trait unlikely. Family may be at risk for hemoglobin C diseases.
FAE + Var	Hemoglobin E and unidentified variant trait. No clinical implications for E trait; clinical effects from variant trait unlikely.
FAS	Hemoglobin S trait. No clinical implications for child. Family may be at risk for sickle cell disease.
FAE	Hemoglobin E trait. No clinical implications for child. Family may be at risk for hemoglobin E/β-thalassemia[a], a significant hemoglobin disease.
FAC	Hemoglobin C trait. No clinical implications for child. Family may be at risk for homozygous C, a mild to moderate hemolytic anemia or hemoglobin SC, a moderate to severe form of sickle cell disease.
FAD	Hemoglobin D trait. No clinical implications for child. Homozygous state is benign; however, family may be at risk for hemoglobin SD, a moderate to severe form of sickle cell disease.
FA + Var	Unidentified variant trait. Clinical effects unlikely.

[a] Decreased production of β globin chains; benign to severe anemia. Significant interaction with other β chain variants such as hemoglobin S, E, and D.
[b] Decreased production of α globin chains; benign to severe anemia depending on how many of the four α globin genes are affected.

APPENDIX B: Newborn Hemoglobin Screening – Infants Detected by Phenotype and Race/Ethnicity

January through December 2014; Number of Infants = 87,415

Phenotype	Total	White	Black	Asian	Nat. Am.	Other[a]	Unk[b]	Hispanic[c]
FSS	6	0	5	0	0	0	1	0
FSS + Bart's	1	0	1	0	0	0	0	0
FS-	1	0	0	0	0	1	0	0
FSC	2	0	2	0	0	0	0	1
FSA	2	0	1	0	0	1	0	0
FSE	1	0	0	1	0	0	0	0
FSD	1	0	0	0	0	1	0	0
FSV	1	0	0	0	0	0	1	1
FAA + CS + High Bart's	1	0	0	1	0	0	0	0
FAA + High Bart's	3	0	0	1	0	2	0	0
FAE + High Bart's	2	0	0	2	0	0	0	0
FCA	2	0	2	0	0	0	0	0
FCC	2	0	1	0	0	1	0	1
FDD	1	0	0	1	0	0	0	0
FEE	6	0	0	4	0	2	0	0
FEE + Bart's	1	0	0	1	0	0	0	0
FAE + CS + Bart's	3	0	0	1	0	0	2	0
FA + CS + Bart's	10	2	1	4	0	3	0	0
FAS + Bart's	8	0	3	0	0	5	0	0
FAE + Bart's	9	0	0	4	0	4	1	0
FAA + Bart's	245	13	48	71	1	97	15	25
FAS	483	43	187	4	4	183	62	106
FAE	258	12	5	115	1	116	9	19
FAC	95	5	39	0	0	44	7	19
FAD	37	17	0	9	2	8	1	4
FA + Var	184	86	7	7	1	33	50	59
Total	1,365	178	302	226	9	501	149	235

[a] Includes other races not listed above and multiracial (more than one race designation on the screening form).

[b] Unknown race (no designation made).

[c] Hispanics can be of any race; they are included in figures to the left.

APPENDIX C: Infants Detected by Newborn Screening 2008 - 2013

DISORDER	2008*	2009	2010	2011	2012	2013
Amino Acid Disorders:						
• Phenylketonuria (PKU)	6	6	7	6	9	5
• Maple Syrup Urine Disease (MSUD)	2	0	0	1	0	3
• Citrullinemia (CIT)	0	0	0	1	0	0
• Tyrosinemia type 1 (TYR-1)	1	0	0	1	0	1
• Homocystinuria (HCY)	0	0	0	1	1	0
Biotinidase Deficiency (BIO)	0	0	0	2	3	1
Congenital Adrenal Hyperplasia (CAH)	8	4	3	11	10	6
Congenital Hypothyroidism (CH)	84	73	77	104	117	98
Cystic Fibrosis (CF)	16	14	23	17	16	20
Fatty Acid Oxidation Disorders:						
• Medium chain acyl-CoA dehydrogenase (MCAD) deficiency	5	4	7	5	4	2
• Very Long Chain acyl-CoA dehydrogenase (VLCAD) deficiency	0	2	3	1	3	1
• Carnitine uptake deficiency (CUD)	0	0	1	0	0	0
Galactosemia (GALT)	2	1	3	11	17	6
Hemoglobinopathies (Hb)						
• Sickle Cell Disease	9	7	9	7	12	8
• Hemoglobin E-beta thalassemia	1	1	1	3	2	2
• Hemoglobin H disease	6	5	6	4	7	6
• Other moderate to severe hemoglobinopathies	3	4	1	1	3	1
• Mild hemoglobin conditions & traits (excluded in summaries below)	1,415	1,158	1,199	1,130	1,244	1,330
Organic Acid Disorders:	0					
• Glutaric acidemia type 1 (GA-1)		3	0	0	0	0
• Methylmalonic acidemia (MUT)		0	1	2	2	1
• Propionic acidemia (PROP)		0	0	2	1	0
• Beta-ketothiolase deficiency (BKT)		1	1	0	0	0
• Isovaleric acidemia (IVA)		0	0	0	0	1
Non-panel Disorders:	0					
• 3-methylcrotonyl-CoA carboxylase (3-MCC) deficiency		1	0	1	1	3
• Glutaric acidemia type II (GA-II)		0	1	0	0	0
• Methylmalonic acidemia Cbl C		0	1	3	0	1
• 2-methylbutyryl-CoA dehydrogenase (2-MBD) deficiency		0	0	3	0	0
• 3-methylglutaconic aciduria (3-MGA)		0	0	1	0	0
• Methionine adenosyltransferase (MAT-II) deficiency		0	0	0	1	0
Total Infants Detected**	143	126	145	188	209	166
Total Infants Screened	86,058	84,871	83,086	84,918	86,180	85,427
Overall frequency**	1 in 601	1 in 674	1 in 573	1 in 452	1 in 412	1 in 515

*expanded MS/MS screening began mid-year

** excludes mild hemoglobin conditions & traits

APPENDIX D: History of Conditions Added to Washington's Newborn Screening Panel

In 1963 phenylketonuria (PKU) screening was offered through the state's Public Health Laboratory as a voluntary service. In 1967 the state legislature passed a statute that directed the Department of Health to "...promote screening tests of all newborn infants..." for PKU. Despite these efforts, however, many infants were not being screened and the quality of screening was highly variable between sites. As a result, some affected infants were not detected in time and suffered the irreversible mental and physical damage caused by PKU. This led the legislature to adopt revisions to the statute in 1976 to require screening of all infants unless the parents refused on religious grounds. The legislation also gave authority to the Board of Health to determine which other disorders should be included in the screening and to adopt rules to achieve the intent of the law. The table below is a timeline of additional disorders added to the panel:

YEAR	DISORDERS ADDED
1963	Phenylketonuria (PKU) - test available, voluntary
1967	- statute adopted, promotes screening
1976	- statute revised, mandates screening & BOH given authority to add conditions; adopt rules to carry out intent of statute
1978	Congenital hypothyroidism (CH)
1984	Congenital adrenal hyperplasia (CAH)
1991	Hemoglobinopathies (HB)
2004	Biotinidase deficiency (BIO)
	Galactosemia (GALT)
	Homocystinuria (HCY)
	Maple syrup urine disease (MSUD)
	Medium-chain acyl-CoA dehydrogenase (MCAD) deficiency
2006	Cystic fibrosis (CF)
2008	Amino acid (AA) disorders:
	Arginosuccinic acidemia (ASA)
	Citrullinemia (CIT)
	Tyrosinemia type 1 (TYR-1)
	Fatty acid oxidation (FAO) disorders:
	Carnitine uptake deficiency (CUD)
	Long-chain L-3-hydroxy acyl-CoA dehydrogenase (LCHAD) deficiency
	Trifunctional protein (TFP) deficiency
	Very long chain acyl-CoA dehydrogenase (VLCAD) deficiency
	Organic acid disorders (OA)
	3-hydroxy-3-methylglutaric aciduria (Hydroxymethylglutaric aciduria - HMG)
	Beta-ketothiolase (BKT) deficiency
	Glutaric acidemia type 1 (GA-1)
	Isovaleric acidemia (IVA)
	Methylmalonic acidemia - mutase (MUT) deficiency
	Methylmalonic acidemia – cobalamin A, B (Cbl A,B) deficiency
	Multiple carboxylase deficiency (MCD)
	Propionic acidemia (PROP)
2014	Severe Combined Immunodeficiency (SCID)