Appendix I

Data and Methods Used in OTA's Cost-Effectiveness Analysis of Strategies for Newborn Screening

This appendix presents information on sources of data and methods of calculation used in OTA's cost-effectiveness analysis of strategies for newborn screening, which is presented in chapter 5. That chapter considered seven different strategies offering different combinations of tests for phenylketonuria (PKU), congenital hypothyroidism, galactosemia, maple syrup urine disease (MSUD), and homocystinuria. Information about the detection and treatment of these and other disorders is presented in appendix H.

Specimen Collection Costs

The vast majority of first blood specimens for newborn screening are collected in the hospital before a newborn infant is discharged. The only published data on costs of specimen collection in the hospital are from a time study at three Wisconsin hospitals (47). The average cost of first specimen collection in that study was found to be $4.60 (in 1982 dollars), which included the cost of drawing blood, administration, medical recordkeeping, supplies, billing, and overhead. Using the medical care component of the Consumer Price Index, OTA inflated the $4.60 from this study to its 1986 value, $6.07, and used this to represent the cost of first specimen collection in the base case analysis.

Most second specimens are likely to be collected outside the hospital, possibly during the first recommended well-child visit at the physician's office or clinic, and would therefore entail different costs than first specimen collection. The recommended schedule of well-child visits offered by the American Academy of Pediatrics Committee on Practice and Ambulatory Medicine specifies that infants should be examined by a physician during the first month after birth and that tests for PKU and congenital hypothyroidism should be done at about 2 weeks of age (20). [1] Second specimen collection performed during such visits would then be additional to the services performed during the visit, and would not require a separate visit to the physician's office solely for that purpose. The assumption in OTA's analysis, therefore, was that the costs of collecting a second specimen would not normally include the separate cost of an office visit to the physician. Data on the costs of specimen collection performed in a physician's office are not available, so it is unknown whether these costs are greater or less than the collection costs in a hospital.[2] For OTA's analysis, it was assumed that the cost of collecting a second specimen would be similar to the cost of collecting the first.[3]

Laboratory Testing and Followup Costs

OTA estimated the resource costs of newborn screening for PKU, congenital hypothyroidism, galactosemia, MSUD, and homocystinuria using data provided by three State newborn screening programs: Washington (609), Wisconsin (259), and Iowa (256). OTA asked the directors of each of these programs to estimate the cost of resources (divided into personnel time, amounts of supplies and reagents, and major equipment) applied to laboratory testing and followup for each of these conditions, and requested an approximate breakdown of cost items in these categories. The results reflect best available estimates of the value of resources used to screen for these various disorders. Using these data, OTA made an effort to include only the appropriate types of data in each category and to delete irrelevant and duplicative items.

Based on these three States' data, the combined cost of laboratory detection and followup for PKU and congenital hypothyroidism[4] ranged from **$3.88 to $8.16** per specimen, giving a mean of **$5.65, which was**

[1] For more information on the recommended frequency and content of well-child care, see ch. 6 of this report

[2] Both, however, may be different from actual charges that families pay for the service. Since charges affect only incomes and budgets, rather than resource costs, they are not considered here.

[3] In practice, the cost of second specimen collection in a physician's office may actually be less than in a hospital. For comparison, under the Medicare program, physicians are currently reimbursed $3.00 for handling a blood specimen that will be sent to an outside laboratory for analysis (438). Moreover, newborn blood specimens are collected onto filter paper cards, which are generally easier to handle and transport than whole blood collected in tubes, so handling a newborn screening specimen may be less costly than handling other blood specimens collected by the physician, and can actually be transported by regular mail service.

[4] Since screening for PKU and congenital hypothyroidism is available in all States, OTA combined the costs of screening for these conditions into a single estimate.

used in OTA's base case analysis to estimate the cost of detection and followup of PKU and congenital hypothyroidism. The cost of laboratory detection and followup for galactosemia ranged from $1.25 to $1.60 per specimen in these data, and for MSUD, from $0.98 to $1.84 per specimen. OTA's base case analysis used the simple averages of these estimates: $1.43 for galactosemia and $1.41 for MSUD. Only one estimate for homocystinuria testing and followup was available—$0.93 per specimen—and that was used in OTA's base case analysis.

The differences among the three State newborn screening programs in estimated screening and followup costs may result from actual technical differences in testing and from different ways of estimating amounts and costs of resources needed for testing and followup. In addition, a large portion of their estimated costs may be fixed costs, which do not change with changes in the number of specimens analyzed. Further, costs of equipment and personnel may, to some extent, be fixed costs in screening programs, while costs of supplies and reagents (generally the least costly components of testing) would be more closely related to the specimen volume. Because some percentage of costs is fixed, unit costs in small volume programs are not likely to correspond to unit costs in large volume programs.

Another possible cause of the variability in unit costs among these data may be real differences in organization and staffing among the programs, as well as artificial differences in reporting (e.g., inclusions of some types of costs in one program and not another) or differing methods for allocating common or overhead costs. The result is a combination of methodologies. The costs of laboratory equipment, for example, were particularly difficult to assess, since ways of determining equipment costs involved different interpretations of what would be considered "major" equipment and different ways of valuing them.

Treatment Costs for Cases Detected by Newborn Screening

Estimates of treatment costs per case of PKU and congenital hypothyroidism used in OTA's analysis are shown in table I-1. The undiscounted costs and their 1982 values were derived from two studies in Wisconsin (46,47). The base case and the best case analyses applied a 7-percent discount rate to these costs, while the worst case analysis applied a 10-percent discount rate.

Table I-1.—Costs of Treatment for PKU and Congenital Hypothyroidism

Year of cost	Undiscounted total treatment costs	costs discounted at 70/0	costs discounted at 100/0
Phenylketonuria: age 0-20			
1982 dollars	$81 ,600'	$40,830	$32,350
1986 dollars		$53,855	$42,670
Congenital hypothyroidism: age 0-70			
1982 dollars	$11,240[b]	$ 3,230	$ 2,270
1986 dollars		$ 4,260	$ 3.588

[a] H s Barden, R Kessel, and V E. Schuett, "The Costs and Benefits Of Screening for PKU in Wisconsin, " *Social Biology* 31(12) 1-17, 1984
[b] H.S Barden and R Kessel , "The Costs and Benefits of Screening for Congenital Hypothyroidism in Wisconsin, " Social *Biology* 31(3-41 185200 1984

SOURCE Of fice of Technology Assessment, 1988

Treatment costs for PKU include the following costs spread over the first 20 years of a patient's life[5]: a low-phenylalanine dietary supplement beginning in the first few weeks of life[6] (averaging $2,914 per year, undiscounted 1982 dollars) and clinical followup—including blood testing, travel, ' and consultation with physicians, nutritionists, and genetic counselors. Treatment costs for congenital hypothyroidism include the following costs: clinical followup—including laboratory testing, physician fees, travel—and medication (thyroxine supplements cost approximately $20 per year, undiscounted 1982 dollars).

OTA inflated these estimates of PKU and congenital hypothyroidism treatment costs to their **1986** values using the medical care component of the Consumer Price Index. In 1986 dollars, total costs of PKU treatment were estimated at $53,855 using a 7-percent discount rate and $42,670 using a 10-percent discount rate. Total costs of congenital hypothyroidism treatment were estimated at **$4,260 and $3,488,** respectively.

Comparable data on treatment costs for galactosemia, MSUD, and homocystinuria are not available in

'The length of time that a given individual with PKU must remain on the diet is still unknown, but preliminary information suggests that beyond age 20 or so, a high phenylalanine level in the blood has little or no effect on mental capacities However, there may be seizures, personality changes, and other effects of discontinuing the diet. Women with PKU should be advised to continue the diet during their childbearing years to minimize the risk of fetal damage Long-term collaborative studies are in progress to determine if there is an age at which it is safe to discontinue the diet (346)

[6] Since the low-phenylalanine products are dietary supplements rather than a complete alternative food source, and individuals with PKU can eat natural foods that have little or no phenylalanine (though these may be somewhat more expensive than other foods), the costs of a normal diet are not subtracted from the cost of a PKU diet

[5] Ideally, travel costs should have been omitted from this analysis, since they are not costs to the health care sector. Since they contributed only $660 undiscounted 1982 costs to the total cost of PKU treatment over 20 years and $780 to the costs of congenital hypothyroidism treatment over 70 years, however, they are not likely to affect the estimate of treatment costs

the literature. Children with galactosemia require no special supplemental diet—just avoidance of foods containing galactose. In OTA's analysis, costs of treatment for galactosemia are approximated by the reported costs of treatment for congenital hypothyroidism (46), which include minor costs for medication and long-term costs of clinical care and monitoring.

Treatment costs for MSUD and homocystinuria in OTA's analysis are approximated by the costs of long-term PKU treatment (47), because patients with MSUD or homocystinuria require a special diet similar to the PKU diet and also require long-term clinical care and monitoring. The diets for MSUD and homocystinuria may be more costly than the PKU diet (and patients with MSUD may have more crises requiring hospitalization, so their treatment may be more expensive than treatment for patients with PKU); but since the lifespan of treated patients with these diseases is unknown, the difference in costs is unknown. In the absence of firm data, OTA assumed that the costs of PKU treatment approximate the cost of MSUD and homocystinuria treatment, and the cost of congenital hypothyroidism treatment approximate the cost of galactosemia treatment,

Health Care Costs Averted by Newborn Screening and Treatment

Individuals with untreated PKU or congenital hypothyroidism, who are mentally retarded in the majority of cases, obviously lead lives that are fundamentally different from those of afflicted individuals in whom the disease has been treated. The societal costs of mental retardation include the added costs of residential care and special education, as well as the loss to society of some potential contribution the afflicted individual might have made with a normal level of intelligence. Some costs may also be borne by the family of the individual with untreated PKU or congenital hypothyroidism (e.g., reduced earning capacity of one or both parents due to the increased demands of raising a mentally retarded child compared to a normal child).

The costs of untreated PKU and congenital hypothyroidism in OTA's analysis, however, include only the major costs to the health care sector broadly defined—in particular, the costs of custodial care and institutionalization and the cost of special education for untreated individuals beyond that required for normal individuals. The costs avoided by newborn screening include the lifelong costs of custodial care and special education associated with untreated disease. The costs averted by treatment of PKU are shown in table I-2, and those averted by treatment of congenital hypothyroidism are shown in table I-3.

In calculating these costs, it is necessary to estimate the expected levels of mental retardation and average survival in untreated individuals. For PKU, OTA used the assumptions of Barden and colleagues that 64 percent of individuals with untreated PKU would be in-

Table 1.2.—Costs of Residential Care and Special Education Averted by Newborn Screening for PKU

Component of cost	Lifetime undiscounted cost per person	Lifetime cost discounted 7%/0		Lifetime cost discounted 10%/0	
		Total cost	PKU cost[a]	Total cost	PKU cost[a]
Residential care and services					
a. Institutional care (assumes 64%/0 of PKU cases institutionalized from age 5 to 70)	***$913,250***	***$259,000***	$166,000	$181,700	$116,288
b. Foster care (assumes 18%/0 of PKU cases receive foster care from age 5 to 20)	$67,000	$31,740	$ 6,000	$23,950	$ 4,311
c. Adult residential care and services (assumes 36%/0 of PKU cases use adult residential care and services from age 20 to 70)	***$176,400***	***$*** 20,010	$ 7,000	$ 9,280	$ 3,341
Special education (by degree of mental retardation)					
a. Severe (64%/0 of PKU cases)	$ 84,110	$42,020	$ 27,000	***$ 32,470***	***$ 20,781***
b. Moderate (20%/0 of PKU cases)	$ 75,530	$36,660	$ 7,000	***$28,040***	***$ 5,608***
c. Mild (16%/0 of PKU cases)	$ 43,270	$ 22,120	$ 4,000	***$ 17,250***	***$ 2,760***
Total cost per case in 1982 dollars			***$217,000***		$153,089
Total cost per case in 1986 dollars[b]			***$246.512***		***$173.909***

[a]Corresponds to the average cost per child with PKU, which is a function of the percent of PKU Individuals requiring institutionalization (see text for explanation)
[b]Inflated from 1982 to 1986 dollars using the Consumer Price Index of 13.6% fOr this period.

SOURCE: Adapted from H.S Barden and R.Kessel, "The Costs and Benefits of Screening for Congenital Hypothyroidism in Wisconsin," *Social* Biology 31(3-4) 185-200, 1984

Table I-3.—Costs of Residential Care and Special Education Averted by Newborn Screening for Congenital Hypothyroidism (CH)

Component of cost	Lifetime undiscounted cost per person	Lifetime cost discounted 7%		Lifetime cost discounted 10°/0	
		Total cost	CH cost[a]	Total cost	CH Cost[a]
Residential care and services					
a. Institutional care (assumes 15°/0 of CH cases institutionalized from age 5 to 70)	$1,845,500	***$324,600***	***$48,690***	$205,400	$30,810
b. Foster care (assumes 25°/0 of CH cases receive foster care from age 5 to 20)	$ 46,680	***$ 32,420***	***$ 8,110***	$ 24,250	$ 6,063
c. Adult residential care and services (assumes 40°/0 of CH cases use adult residential care and services from age 20 to 70)	$ 513,480	***$ 41,280***	***$ 16,510***	$ 17,590	$ 7,036
Special education (by degree of mental retardation)					
a. Severe (1 5°/0 of CH cases)	$ 87,590	***$ 42,690***	***$ 6,400***	$ 32,700	$ 4,905
b. Moderate (25°/0 of CH cases)	$ 79,330	***$ 37,520***	***$ 9,380***	$ 28,440	$ 7,110
c. Mild (40°/0 of CH cases)	$ 44,820	***$ 22,370***	***$ 8,950***	$ 17,300	$6,920
Total cost per case in 1982 dollars,			***$ 98,040***		$62,844
Total cost per case in 1986 dollars[a]			$111,373		$71,391

[a]Inflated from 1982 to 1986 using the Consumer Price Index of 136°o for this period

SOURCE Adapted from H S Barden and R Kessel "The Costs and Benefits of Screening for Congenital Hypothyroidism in Wisconsin *Social Biology* 31(3-41 185200 1984

stitutionalized from age 5 for life, 18 percent would require foster care from age 5 to 20, and 36 percent would require adult residential support services (47). The net average costs of residential care and special education were derived from this same study (47) (given in **1982** dollars and discounted at 7 and 10 percent) and inflated to 1986 values for the OTA analysis. To adjust for the expected lifespan of untreated individuals with PKU, OTA used survival rates based on a study of the age at death for institutionalized individuals with PKU (174); that study generally agrees with previous studies (85).

Costs of untreated congenital hypothyroidism, as in PKU, derive mainly from the attendant costs of mental retardation, but the spectrum of severity is different for congenital hypothyroidism. In these calculations, OTA used the assumptions of Barden and colleagues that 15 percent of individuals with untreated congenital hypothyroidism would be institutionalized from age 5 for life, **25** percent would require foster care from age 5 to 20, and 40 percent would require adult care and services from age 20 for life (46). These costs were combined with the additional cost of special education (46) (given in 1982 dollars and discounted at 7 and 10 percent) and inflated to 1986 values. To take into account the lifespan of individuals with congenital hypothyroidism, survival was estimated to be 95 percent of normal survival rates (368).

The costs of untreated galactosemia, MSUD, or homocystinuria are more difficult to quantify. No data are currently available to estimate the cost of the progressive deterioriation and almost certain death, as occur in the majority of cases of galactosemia or MSUD, or the long-term disabilities and risk of premature death, as in cases of homocystinuria. For that reason, OTA's analysis did not quantify costs of untreated galactosemia, MSUD, or homocystinuria.

The cost of institutional care for the mentally retarded was estimated at $36,500 per year per patient in 1982 dollars (47). This cost was derived from an estimate of the Wisconsin Center for Developmental Disabilities and compared with $32,759, the yearly cost of residential care derived from national data (362). In Barden's analysis, $4,000 was subtracted from the annual cost of institutionalization to account for the costs of care for a normal individual (603).

OTA calculated the costs of institutionalization per patient using the annual cost of institutional care per patient, the estimated survival of individuals with PKU or congenital hypothyroidism, and the percentage of survivors requiring institutional care. The costs of institutionalization reported by Barden et al. (47) were inflated to 1986 dollars in OTA's analysis using the overall Consumer Price Index.

The annual cost of foster care was estimated to be $9,000, or $5,000 if personal consumption costs are deducted (47). In PKU, the discounted cost of foster care amounts to $32,000 (in 1982 dollars) over the period from age 5 to 20 discounted at a 7-percent rate.

The annual cost of adult residential care and services was estimated at $12,000 (1982 dollars) per person, but this does not include costs of associated community services, special transportation, or vocational rehabilitation (47). For individuals with untreated PKU, the cost of adult residential care services is low because of the low survival rate to adulthood.

The added costs of special education for survivors were derived from a nationwide study conducted by the Rand Corp. **(313) and** expressed in 1982 dollars in the studies by Barden and colleagues (46,47). The original costs in the Rand report were expressed in 1978 dollars and were inflated by Barden et al. to 1982 dollars using the GNP deflator. This method increased these costs by 34 percent for this period, whereas the overall Consumer Price Index would have inflated them by 48 percent for this same period (721),[8] For OTA's analysis, the costs of institutionalization, foster care, adult residential care and services, and special education were inflated to 1986 levels using the overall Consumer Price Index.

[8]This difference in inflation methods for 4 of the 8 years for which they are adjusted is not likely to alter the total discounted cost of special education in these cases

Calculation of Net Costs and Effectiveness in the Base Case and Sensitivity Analyses

The calculation that OTA used to estimate the overall costs or savings and number of cases detected per 100,000 infants screened is shown by the figures for Strategy I (a single specimen to test for both PKU and congenital hypothyroidism) in table I-4. The total cost of newborn screening and treatment, consisting of the costs of specimen collection, lab testing, followup, and treatment, amounts to $1,716,000 per 100,000 infants screened to identify and treat approximately 34 cases of PKU and congenital hypothyroidism when compared to no screening at all. The expected cost averted by such screening and treatment amounts to $4,935,000 per 100,000 infants screened, yielding a net savings of $3,219,000.

Table 1-4.—Costs and Effectiveness of Seven Newborn Screening Strategies Compared to No Screening (1986 dollars)

		Strategy I	Strategy II	Strategy III	Strategy IV	Strategy V	Strategy VI	Strategy VII
	1st specimen	PKU + CH	PKU + CH	PKU † CH	PKU + CH	PKU + CH	PKU, CH GA, MSUD	PKU, CH, GA, MSUD
	2nd specimen.	None	PKU + CH on all Infants	PKU + CH on early discharge Infants only	CH only on all infants	PKU, CH HC on all Infants	None	PKU, CH, and HC on all infants
1	Specimen-collection cost per 100,000 Infants screened	$ 607,000	$1.214000	$ 858298	$1,214,000	$1214000	$ 607,000	$1,214,000
2	Lab testing and followup cost per 100,000 Infants screened	$ 565,000	$1.130.000	$ 799910	$ 875000	$1,223000	$ 849,000	$1,507,000
3	Number of cases detected per 100,000 infants screened	34.6	366	359	363	371	364	389
4	Treatment cost for cases detected among 100 000 Infants screened	$ 544.000	$ 568.000	$ 560.000	$ 51.000	$ 594,000	$ 572,000	$ 622,000
5	Total cost of screening and treatment [1+2+4]	$1716,000	$2.912,000	$2,217000	$2.640.000	$3,031,000	$2,028,000	$3,343,000
6	Costs averted [custodial and special education costs associated with untreated disease]	$4,935,000	$5.198,000	$5,106,000	$5124,000	$5,198000	$4,935,000	$5,198,000

Al) breviations PKU = phenylketonuria CH = congenital hypothyroidism HC = homocystinuria GA = galactosemia MSUD = maple syrup **urine disease**

SOURCE Office of Technology Assessment 1988