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Cost-Effectiveness of Expanded Newborn Screening in Texas

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ABSTRACT

Objective: Texas House Bill 790 resulted in the expansion of the newborn screening panel from 7 disorders to 27 disorders. Implementation of this change began in 2007. The objective of this study was to estimate the incremental cost-effectiveness of the expanded newborn screening program compared with the previous standard screening in Texas. **Methods:** A Markov model (for a hypothetical cohort of Texas births in 2007) was constructed to compare lifetime costs and quality-adjusted life-years (QALYs) between the expanded newborn screening and pre-expansion newborn screening. Estimates of costs, probabilities of sequelae, and utilities for disorder categories were obtained from a combination of Texas statistics, the literature, and expert opinion. A baseline discount rate of 3% was used for both costs and QALYs, with a range of 0% to 5%. Analyses were conducted from a payer's perspective, and so only direct medical cost estimates were included. **Results:** The lifetime incremental cost-effectiveness ratio for expanded versus pre-expansion screening was about $11,560 per QALY. The results remained robust to both deterministic and probabilistic sensitivity analyses. **Conclusions:** Expanded newborn screening does result in additional expenses to the payer, but it also improves patient outcomes by preventing avoidable morbidity and mortality. The screened population benefits from greater QALYs as compared with the unscreened population. Overall, expanded newborn screening in Texas was estimated to be a cost-effective option as compared with unexpanded newborn screening.

Keywords: children, cost-effectiveness analysis, health economics methods, model, quality-adjusted life-years.

Background

Newborn screening involves laboratory analysis of blood samples from newborns to detect inborn errors of metabolism and allows timely diagnosis of serious and life-threatening conditions. Screening should be conducted in the first week of a baby's life to ensure treatment initiation before the age of 4 weeks. Timely treatment helps prevent irreversible mental retardation, physical disability, and death in most cases [1]. Newborn screening started in the United States in early 1960s when Dr. Robert Guthrie developed a bacterial inhibition assay for identifying infants with phenylketonuria (PKU). His technique of collecting blood samples on filter paper made it possible to implement PKU screening at the population level [2]. Gradually, more disorders were added to the newborn screening panel.

The use of tandem mass spectrometry (MS/MS) has made it possible to screen for as many as 50 disorders by using the same blood specimen. With the ability to screen for more disorders, most US states expanded their newborn screening panel although the expansion process varied greatly across states. The economic viability of these expansions has been studied by many researchers. In 2002, Schoen and Baker [3] reported that screening for multiple disorders with MS/MS yields an incremental cost-effectiveness ratio (ICER) of $5827 per quality-adjusted life-year (QALY). Of the newly added conditions, medium-chain acyl-CoA dehydrogenase deficiency (MCADD) is the most common, affecting about 1 in 20,000 of all newborns in the country. A few studies have been based on the cost-effectiveness of this condition alone. Insinga et al. [4], Venditti et al. [5], and Tran et al. [6] reported that universal screening for MCADD by using MS/MS is a cost-effective option. Two studies based in California focused on MCADD and several other conditions and reported that MS/MS screening is a cost-effective strategy for most conditions, except congenital adrenal hyperplasia or galactosemia [7,8]. A Canadian study assessed the expansion of the existing screening system in Ontario and concluded that the average cost of screening for PKU plus 14 other disorders is Can $95,000 per life-year gained [9]. It is important to note that in each of the studies, comparisons may differ. Reasons for this include differences in the base case, patient population, and number of disorders already being screened, and measures of cost-effectiveness used. Such differences will automatically impact the results of an economic analysis that is always relative to the baseline comparator.

The newborn screening panel in Texas was expanded when House Bill 790 mandated that the state should offer screening for at least 28 conditions recommended by the American College of Medical Genetics [10]. In 2007, Texas began to screen for 27 of the 29 recommended conditions. This was a large increase from the 7 disorders that were included in the panel prior to this expansion. Texas performs two screens on newborns by using separate blood samples obtained at the ages of 24 to 48 hours and 7 to 14 days, respectively. Blood samples from infants who test positive after the second screen need to be sent for confirmatory testing.

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† This study was completed while the author was at the University of Texas at Austin.

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Objective

The main objective of this study was to report the incidence of various newborn screening disorders for the 2007 birth cohort in Texas and to estimate the cost-effectiveness of the expanded newborn screening by using Texas-specific data.

Methods

Overview

We developed a cost-effectiveness Markov model by using TreeAge to represent the screening outcomes and the sequelae encountered by children who are diagnosed with one of the metabolic disorders that are included in the expanded newborn screening panel of Texas. Because of lack of sufficient information on incidence and sequelae, we could include only the following disorders in our analysis: arginosuccinic acidemia (ASA), citrullinemia (CIT), homocystinuria (HCY), maple syrup urine disease, MCADD, glutaric acidemia type I (GA-I), and classical organic acid disorders (COAD) (including methylmalonic acidemia, propionic academia, and isovaleric acidemia). One or more disorders were grouped together if they shared physiological similarities. The model included a hypothetical cohort of infants born in Texas in 2007, since newborn screening was expanded in January of that year. We adopted the perspective of the payers in Texas and discounted the costs and QALYs at a base rate of 3%.

Model assumptions

The following assumptions were used while conducting the cost-effectiveness analysis:

1. A child can have only one metabolic disorder.
2. Testing is timely (specimens obtained within 24–48 hours for first screen and within 7–14 days for second screen), and testing methods are appropriate (i.e., with high sensitivity and specificity).
3. MS/MS is used for screening for the disorders included in this study.
4. In an individual experiencing more than one sequela, disutility caused by the most debilitating sequela also includes the disutility caused by other, less debilitating comorbidities.
5. Newborn screening in Texas is universal.

Cycle length, termination condition, and discounting

Each cycle length was 1 year. Half-cycle corrections were used for initial values of recurring costs such as the costs of special diet and medications. One-time costs incurred in the first year of life, such as the costs of screening and diagnostic testing, however, were not subject to half-cycle correction. A discount rate of 3% was used, and all costs were adjusted to 2007 USD. The Markov model was terminated when 99.99% of the cohort had entered the "dead" state.

Model structure

As shown in Figure 1, the model structure included two main branches, one each for the expanded and the unexpanded screening programs. Subbranches representing six disorder categories (based on common physiological characteristics) and the healthy state were used to compare the two scenarios. An infant could either be affected with one of the screened disorders or be healthy. A large majority of healthy infants should have a negative screen result, while some may have a false-positive screen result (positive screen results that come out negative after confirmatory testing). Because the sensitivity of screening via MS/MS is close to 1.0, we chose not to include a branch for false-negative results. Figure 2 shows an example of a disease-specific subtree for HCY. HCY is

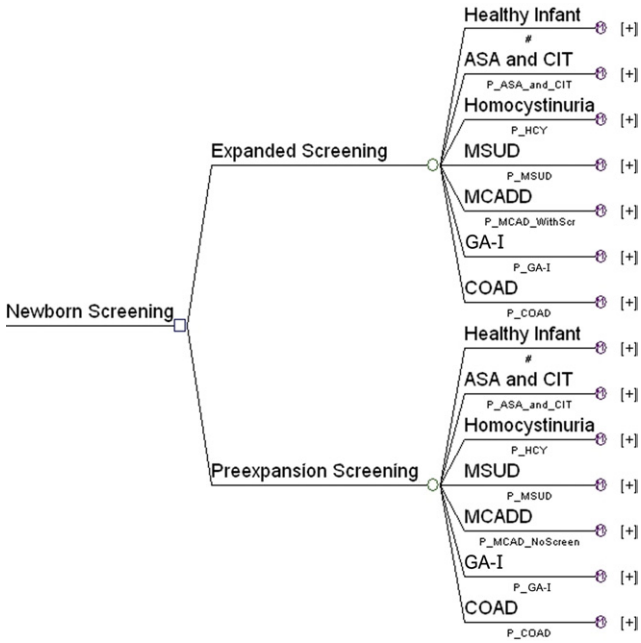

Fig. 1 – ASA, arginosuccinic acidemia; CIT, citrullinemia; COAD, classical organic acid disorders; GA-1, glutaric acidemia type I; HCY, homocystinuria; MCADD, medium chain acyl-CoA dehydrogenase deficiency; MSUD, maple syrup urine disease; P_disorder name, probability of disorder.

an enzyme deficiency disorder that may be grouped with other urea cycle disorders. Because of some unique sequelae of this disorder, it was analyzed as a separate condition. Accumulation of homocystine may cause mental retardation, lens abnormalities, and skeletal abnormalities. Lens abnormalities can be corrected, and so occur in only one cycle of the structure. Premature death may occur because of thromboembolism (blood clot formation). Treatment for HCY includes restricted diet and B_6, B_{12}, and betaine supplementation. In addition, treatment may include cystine in some cases.

Markov states

A healthy infant could either test negative (which is true in most cases) or test false positive. In the event of a false-positive screen, the infant would have to undergo confirmatory testing. The model accounts for the cost and disutility associated with a false-positive screen in the first year of life. Once it is confirmed that the infant does not have the suspected disorder, there is no more costs or disutility allocated to a false-positive case.

True-positive cases would incur the cost and disutility associated with confirmatory testing in the first year of life, as well as treatment costs and loss of quality of life because of their condition for the rest of their lives.

All individuals in the hypothetical cohort were exposed to the risk of "all-cause mortality," which estimates the average risk of death, based on age and sex, by using US Census estimates. Those with one of the conditions included in the newborn screening panel had an additional risk of dying from their disease. This approach was used to ensure a more realistic estimate of the effect of screening.

Event probabilities

The probability of testing positive for any one of the disorders was equal to the prevalence of that particular disorder. The model structure for the unexpanded screening was *very similar* to that for