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Modeling the cost–benefit of nerve conduction studies in pre-employment screening for carpal tunnel syndrome

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Evanoff B, Kymes S. Modeling the cost–benefit of nerve conduction studies in pre-employment screening for carpal tunnel syndrome. *Scand J Work Environ Health*. 2010;36(4):299–304.

Objective The aim of this study was to evaluate the costs associated with pre-employment nerve conduction testing as a screening tool for carpal tunnel syndrome (CTS) in the workplace.

Methods We used a Markov decision analysis model to compare the costs associated with a strategy of screening all prospective employees for CTS and not hiring those with abnormal nerve conduction, versus a strategy of not screening for CTS. The variables included in our model included employee turnover rate, the incidence of CTS, the prevalence of median nerve conduction abnormalities, the relative risk of developing CTS conferred by abnormal nerve conduction screening, the costs of pre-employment screening, and the worker's compensation costs to the employer for each case of CTS.

Results In our base case, total employer costs for CTS from the perspective of the employer (cost of screening plus costs for workers' compensation associated with CTS) were higher when screening was used. Median costs per employee position over five years were US$503 for the screening strategy versus US$200 for a no-screening strategy. A sensitivity analysis showed that a strategy of screening was cost-beneficial from the perspective of the employer only under a few circumstances. Using Monte Carlo simulation varying all parameters, we found a 30% probability that screening would be cost-beneficial.

Conclusions A strategy of pre-employment screening for CTS should be carefully evaluated for yield and social consequences before being implemented. Our model suggests such screening is not appropriate for most employers.

Key terms cost–benefit analysis; CTS; economic evaluation; electrodiagnostic study; musculoskeletal disorder; MSD; post-offer pre-placement screening.

The yield and cost–benefit of pre-employment screening strategies for occupational diseases are rarely subjected to formal analysis (1). We developed a dynamic decision analytic model to estimate the cost–benefit of pre-employment nerve conduction testing as a screening tool for carpal tunnel syndrome (CTS) in the workplace. CTS is a major health concern in certain occupations, resulting in frequent time away from work and high workers' compensation costs (2, 3). Pre-employment screening with electrodiagnostic studies (EDS) to assess nerve conduction has been promoted as a strategy to reduce CTS in jobs requiring intensive hand activity. The rationale for this practice is that workers with abnormal median nerve conduction are at an increased risk of developing CTS, so an employer's overall rate of CTS can be reduced by excluding workers with impaired nerve function from hand-intensive jobs (4–6). Court decisions in the United States support the practice of excluding workers from jobs based on the results of nerve conduction testing (7). A number of employers in the USA now routinely test new workers with EDS and make hiring decisions based on the results. However, this practice is controversial (8, 9), and there has been little evaluation of its diagnostic test yield or cost–benefit outcome.

In the only formal cost–benefit evaluation of post-offer, pre-placement screening for CTS, Franzblau and colleagues (10) evaluated the costs of such a screening and job placement strategy. They analyzed retrospective data from 2150 employees in a single automobile parts manufacturer. In this company, all new employees were

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screened with EDS, but hiring decisions were not made based on this information. Using workers' compensation claims data and information from the company about the costs associated with screening, Franzblau et al concluded that basing hiring decisions on the results of EDS would not have been cost-beneficial, as the cost of screening all new workers exceeded the cost of the CTS cases that might have been avoided. Furthermore, while workers with abnormal EDS at baseline had an increased risk of developing CTS, the majority of them remained asymptomatic. Most CTS cases actually occurred among workers with normal EDS at baseline. This study used data from a single employer, and the extent to which the results can be applied to other populations is not known.

The aim of our study was to construct a model providing a more generalized cost–benefit estimation of basing worker placement or hiring decisions on screening for CTS. In a hypothetical cohort of new employees, we compared the cost of screening all prospective employees for CTS and not hiring those with abnormal nerve conduction, versus a strategy of not screening for CTS. Variability in the results was assessed with both deterministic and probabilistic sensitivity analyses.

Methods

Model parameters

Baseline inputs to our model and the ranges for deterministic sensitivity analyses are shown in table 1. Values were based on a review of the medical literature and expert opinion. The cost per case of CTS was based on published workers' compensation claims data and chosen to be representative of a total claim cost to the employer or employer's insurer for a case of CTS in the USA, including direct medical and disability costs (3, 10, 11). The annual incidence of CTS in the entire working population (regardless of EDS results) was based on reported workers' compensation claims (3, 10, 12–16). The prevalence of abnormal EDS and the relative risk of developing CTS among asymptomatic individuals with abnormal EDS were estimated from several studies in working populations (10, 17–23), as well as from the authors' own unpublished data from an ongoing prospective study of CTS (data available from corresponding author). The cost of screening was based on data from local employers, occupational health practitioners, and the Franzblau et al study (10). The lower range of this cost estimate represents the lower screening cost that is associated with some portable EDS devices; the upper range is below the normal clinical charges for diagnostic EDS. The annual turnover rate incorporated a wide range of values to represent different industries and employment situations. The analysis was carried out from the perspective of the employer, since employers incur the costs of CTS attributed to work activities, and a screening program designed to reduce CTS in an employed workforce would be paid for by the employer. We chose a wide range of parameters for important inputs including turnover rate and cost of a case of CTS, to make the model inclusive of different work settings and state compensation systems. We arbitrarily chose a five-year time horizon with a one-year time cycle. We modeled a working population of 10 000 workers, with continued hiring to replace workers who left employment. In the base case, future costs were not discounted; however the impact of discounting was tested in sensitivity analyses by varying the discount rate by up to 10%.

Accounting for the impact of assumptions on model outcomes

The validity of any decision analytic model, such as the one we constructed, is limited by the assumptions made regarding the model parameters. Therefore, we evaluated our model using sensitivity analyses to determine the extent to which these assumptions affected the outcome of the model. We conducted one- and two-way sensitivity analyses, in which one or two variables are taken through their entire respective ranges of potential values. For the six model parameters listed in table 1, we ran one-way sensitivity analyses for all model parameters individually, and two-way sensitivity analyses for all combinations of two parameters.

Table 1. Inputs to the decision model, including the base model and the range of inputs used for sensitivity analysis. [EDS=electrodiagnostic studies; RR=relative risk]

	Carpal tunnel syndrome		Electrodiagnostic studies			Annual employee turnover rate
	Cost per case (US$)	Annual incidence	Abnormal EDS		Cost of screening (US$)	
			RR	Prevalence		
Base model	20 000	0.002	4	0.15	150	0.15
Range for sensitivity analysis	7500–30 000	0.001–0.02	3–5	0.05–0.25	120–250	0.0–0.5

Markov model

A Markov model is a mathematical method for estimating the costs and consequences of events that repeat in a cyclical manner, with each set of iterations referred to as a Markov cycle (24). In the context of this simulation, each Markov cycle was considered to be one year, and the events modeled over that year included the annual probability that someone would develop CTS, continue working without developing CTS, and leave work due to reasons other than CTS. The model was constructed as a dynamic cohort to maintain an average employee group of 10 000 workers for the hypothetical employer throughout the simulation period; employees who developed CTS or left employment during each cycle were replaced. We compared a strategy of pre-employment screening for abnormal nerve conduction among all new employees versus a no-screening strategy. Included in the model was the cost of screening additional workers to compensate for those rejected from employment based on their EDS result. Our outcome was the expected incremental cost per employee position. The costs included in the model were the cost of (i) screening new employees and (ii) workers' compensation claims for those who developed CTS. Our Markov model is illustrated in figure 1. We conducted probabilistic sensitivity analysis using Monte Carlo simulations, with 10 000 iterations varying all model inputs simultaneously through their full ranges as listed in table 1. Our decision analytic model was constructed using TreeAge Pro 2009 (TreeAge Software, Inc, Williamsport, MA, USA). Our analyses were guided by published principles of good practice for decision analytic modeling in healthcare evaluations (25).

Results

Base model

The results of our base model comparing a strategy of pre-employment screening versus no screening are shown in table 2. The screening strategy resulted in the rejection of 3279 workers for employment, out of a total of 24 336 workers screened to maintain a population

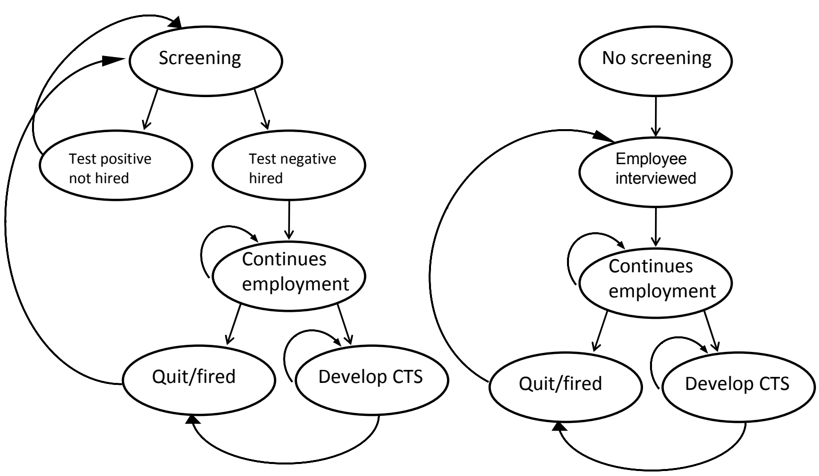

Figure 1. Markov decision model for screening new hires using electrodiagnostic studies (EDS) versus a no-screening strategy. This illustrates the potential path taken by an individual worker. In each year, a worker could remain healthy and continue working, develop carpal tunnel syndrome (CTS) and incur workers' compensation costs, or leave the company due to reasons other than CTS. After the employee developed CTS, they could either keep working or leave the company. Each time a worker quits, is fired, or is not hired due to a "positive" or abnormal EDS, new job applicants must be screened or interviewed for employment.

Table 2. Results comparing a strategy of pre-employment screening for carpal tunnel syndrome (CTS) versus no screening in hiring and maintaining a population of 10 000 workers for five years.

	Outcome					
	Workers considered for employment (N)	Workers rejected for employment due to screening (N)	Cases of CTS in the employed workforce (N)	Costs of all CTS cases treated under workers' compensation (US$)	Cost of screening all new workers (US$)	Total cost of screening plus treatment of CTS cases in workforce (US$)
Screening strategy	24 336	3279	69	1 380 000	3 652 520	5 032 520
No screening strategy	20 691	–	100	2 000 000	–	2 000 000

of 10 000 workers over five years. The screened workers experienced 69 cases of CTS during the five-year period among those employed, versus 100 cases in the unscreened group. Workers' compensation costs of CTS were substantially lower under the screening strategy (US$1 380 000 versus US$2 000 000). However, the cost of screening workers was substantial (US$3 652 520) and far outweighed the cost savings resulting from fewer cases of CTS among the screened employees. In our base case, the expected incremental cost under a screening program was US$303 greater per employee position when compared to the no-screening approach, as screening for CTS incurred more costs than were saved by the reduction in CTS cases among employees. Changing the discount rate had minimal impact on these findings. We also found the screening to be inefficient as 3279 workers were rejected for employment to avoid 31 additional cases of CTS (106 workers rejected for employment for each case prevented in the working population).

Sensitivity analysis

In a one-way sensitivity analysis, only one parameter had a significant impact on the cost–benefit decision: the incidence of CTS among the working population. When this incidence was >0.012 (12 workers' compensation cases per 1000 workers per year), a strategy of screening was favored. In a two-way sensitivity analysis, screening was favored only for combinations of the highest incidence rates and highest costs per case of CTS. In our probabilistic sensitivity analyses using 10 000 Monte Carlo simulations, a strategy of no screening was less expensive for the employer in 70% of the simulations.

Discussion

Although screening for median nerve abnormalities at the time of job hiring is advocated and practiced as a strategy to prevent CTS in the workplace (4–6, 26), there has been little evaluation of this strategy in practice. The only formal evaluation of this practice was performed by Franzblau et al (10), who found that such screening was not cost-beneficial for the employer they studied. Our modeling used a wide range of possible values for the cost of a case of CTS, the likelihood of such a case, and the cost of screening. We found that a strategy of post-offer, pre-placement screening for CTS was not cost-beneficial in the majority of models tested. From the perspective of most individual employers, screening for CTS is unlikely to be cost-beneficial.

Although median nerve conduction abnormalities are important criteria for the diagnosis of CTS, most asymptomatic people with such abnormalities remain asymptomatic (10, 18–22). In the screening scenario we modeled, 3279 workers were rejected for employment over five years in order to avoid 31 cases of CTS for an employer. Of these 3279 workers, 56 (1.7%) went on to develop CTS. It is appropriate to ask how great a difference in the risk of future disease must exist between persons hired and persons not hired in an effort to reduce the burden of future disease. From a broader viewpoint, rejecting workers for employment at one employer probably does not reduce the societal burden of CTS in the total workforce. It is likely that rejected job applicants will seek employment with other employers, often performing work with similar risk factors for CTS, and may still develop CTS despite being rejected for employment by one employer. Potential gain for employers must be weighed against societal costs and costs to individual workers, including discrimination and inappropriate referral for treatment (8, 10, 27).

Our study had several limitations that may affect its conclusions. Decision models using different assumptions will arrive at different answers. We chose estimates of costs, prevalence of CTS, and increased risk of CTS associated with abnormalities of nerve conduction from a review of the relevant literature and conversations with clinical experts. We modeled screening from the viewpoint of the employer, since it is employers who make decisions regarding the use of screening among their workforce. This viewpoint does not account for a number of relevant social costs that pertain to the perspectives of individual workers or society at large. There may be additional, unaccounted for costs of screening to the employer; for example, the rejection of an otherwise qualified job candidate due to median nerve abnormality necessitates offering the position to a potentially less qualified candidate with normal median nerve conduction. Although our analysis suggests that pre-employment screening for CTS is not cost-beneficial to the majority of employers, our sensitivity analyses indicate that under some circumstances (high incidence rate of CTS and high cost per case) it could be cost-beneficial for the employer.

As pointed out by de Kort & van Dijk more than a decade ago (1), workplace screening policies are widespread, though they have rarely been subject to formal analysis. Workplace screening policies are common in the United States, where they are used to screen for susceptibility to conditions such as low-back pain, upper-extremity musculoskeletal disorders, allergies to specific compounds, and the ability to safely use a respirator. Available studies of pre-employment screening indicate that the yield of such practices is low. A study examining over 100 000 pre-employment medical examinations in the Netherlands found a low rate of employee rejection (0.6%), and little relationship between job demands and the diagnoses that prompted rejection (28). The use of spirometry and physical examination were found to add little to the detection of relevant medical conditions for clearance to use a respirator (29). Although screening for musculoskeletal disorders is advocated as a way to reduce workers' compensation costs (30), existing screening policies are rarely based on data showing appropriate diagnostic yield or cost–benefit outcome. In a systematic review of assessment for fitness for work, Serra et al (31) found general confusion about the decision-making process used to judge fitness for work and very scarce scientific evidence based on empirical data to support current practices.

Concluding remarks

We conclude that a strategy of post-offer screening for CTS is not cost-beneficial to the majority of employers, and any such screening should be carefully evaluated for economic yield and social consequences before being implemented. The techniques of cost–benefit analysis are not widely used in the evaluation of occupational health and safety policies, but should be used more widely to guide rational practice.

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