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AN ECONOMIC ANALYSIS OF

TEXAS' MEASLES VACCINATION PROGRAM:

1990-1996

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AN ECONOMIC ANALYSIS OF TEXAS' MEASLES VACCINATION PROGRAM: 1990-1996

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

In order to get the most benefit for society out of limited resources, public health departments must examine the costs and benefits of their activities to determine the most cost-effective method to allocate these scarce resources. The use of economic analysis can inform and help clarify the criteria upon which decisions are to be made. (CDC, 1996). The resources used to produce most goods and services in society are efficiently allocated through markets. However, markets can fail to efficiently provide goods and services that largely benefit individuals other than the consumer. The types of goods and services that public health departments provide often fall into that category. Cost-benefit analysis is one type of economic decision-making tool used when market forces are not in control. Cost-benefit analysis (CBA) places a dollar value on the costs and benefits of each outcome so they can be compared. This type of economic analysis can then be taken one step further. An incremental or marginal analysis can determine changes in the relative costs and benefits' resulting from increase or decreases in the amount of resources used in a program. Such an analysis should be part of the decision making process, so that scarce resources can be used efficiently.

This paper examines not only the costs and benefits of the measles immunization program in Texas but also, the expansion of the program in the 1990's. The most significant changes in Texas' immunization program took place in 1994 as a result of the measles outbreak of 1989-1990. The years 1992, 1993, 1994 and 1996 were chosen for this analysis because of the difference in immunization rates, incidence rates and the level of State funding. This time period represents the most dramatic changes to these three areas.

Since the measles vaccination was put into use in 1963, the number of measles cases in the United States has decreased dramatically. An average of 450 measles-associated deaths was reported each year between 1953 and 1963. (TDH, unpublished). Widespread use of the vaccine has led to a 95% reduction in measles compared with the pre-vaccine era. (TDH, unpublished). However, during 1989-1990, the number of measles cases and deaths rose sharply. During 1989, more than 18,000 cases and 41 deaths were reported. The largest number of reported cases since 1978 and the largest number of deaths in two decades in the U.S. (National Vaccine Advisory Committee, 1991).

The major cause of the epidemic of 1989 and 1990 was a low vaccination rate among preschool children. (TDH, unpublished). The Centers for Disease Control and Prevention (CDC) estimates national measles vaccine coverage for 2-year-olds in 1985 was 61%, compared with 82% in 1991 and 1992. (CDC, 1994). The CDC has set a goal of 90% of 2-year-olds to be immunized against measles, mumps and rubella.

Texas reported 11% of all measles cases in the U.S. between 1989 and 1990, although it only accounted for 7% of the total U.S. population. (Schulte et al., 1996). This is likely due to the fact that immunization rates were low throughout the state. In 1989, only 66% of the children in Dallas and 58% in Houston were estimated to be immunized against polio, diphtheria, pertussis, tetanus, measles, mumps, and rubella by the age of two. Nationally, immunization rates were estimated to be 70% at the same time. (Schulte et al., 1996).

This paper will proceed as follows. Two benefit/cost studies will be outlined in the background section. These studies compare the total benefits and costs of current vaccination programs to no vaccination program. Then, a history of Texas' measles vaccination program will be discussed. It will explain how the measles outbreak of 1989-1990 brought about organizational and financial changes to the immunization program within the Texas Department of Health (TDH).

In the method section, the disease costs and costs associated with a vaccination program are used to calculate a benefit/cost ratio. The changes in immunization rates and the associated marginal costs and benefits are then compared.

The results of the CBA and marginal analysis indicate that the benefit to cost (B/C) ratios range from 17 to 30:1. After reaching an immunization rate of about 81%, marginal benefits become smaller and smaller while the cost of increasing the immunization rate rises.

Finally, the results will be discussed and conclusions made as to the efficiency of Texas' measles vaccination program. There is some evidence that the CDC's goal to immunize 90% of 2-year-old children for measles may not be the most efficient goal for Texas.

BACKGROUND

Although vaccination programs are ideally suited for CBA, the literature contains few such studies. Most previous studies, analyzing immunization programs for individual diseases with single antigen vaccines, calculate benefit-cost ratios between 5:1 and 12:1. This means that between $5 and $12 of benefit are generated for every $1 of cost. (White et al., 1985). These studies compared the total costs and total benefits of a current immunization program to no program.

White et al. (1985) examined the actual and estimated morbidity, mortality, and costs associated with measles, mumps and rubella. The base case of no immunization program was compared to the national immunization program in 1983. Savings in disease treatment costs, lost wages and loss of lifetime earnings due to disability were used to calculate the benefits of a vaccination program. The cost of the vaccination and its administration and the cost of treating any adverse reactions to the vaccine were used to calculate the costs of the vaccination program. White et al. (1985) calculated a benefit-cost ratio of 14:1 for the 1983 measles immunization program. Results for the mumps and rubella component were less significant. (White et al., 1985). This study did not separate the costs associated with administering public vs. private vaccination programs, which can be very different. Total costs and total benefits for the entire program were used to calculate the benefit/cost ratio.

The Battelle Medical Technology Assessment and Policy Research Program conducted a benefit-cost analysis in 1994 to examine the merits of MMR immunizations.

It compared the benefits and costs of the measles, mumps and rubella vaccine with the absence of a vaccine. It examined the hypothetical situation in terms of costs and health benefits of the 1992 birth cohort from birth to 40 years of age. The costs and benefits of a vaccination program were similar to the White et al. study in 1985. They found the benefits outweighed the costs by a ratio of 17.2:1 for a single dose of measles vaccine. The results for the mumps and rubella vaccine were similar. (Battelle, 1994).

Because CBA and marginal analysis can help determine how scarce resources would be best allocated, this paper will assess the efficiency of Texas' measles vaccination program using both methods. Marginal analysis on a state or national level was not found in published literature. This paper's focus will be the public sector of the vaccination program in Texas. We assume that the portion of the population that would be served in public health clinics is where gains in immunization rates have been made.

The National Vaccine Advisory Committee studied the inner-city measles outbreaks in Chicago, Dallas, Los Angeles, Milwaukee, and New York, during 1989 – 1990, and found that 40% to 91% of unvaccinated preschool children who developed measles were enrolled in one or more public assistance programs. These programs include Aid to Families with Dependent Children (AFDC) and the Supplemental Food Program for Women, Infants and Children (WIC). (National Vaccine Advisory Committee, 1991). Since it is assumed that these children would be most likely reached by TDH, WIC offices began immunizing clients and their families in 1993. This committee, also, found that inner-city parents were most likely not to visit a private physician for routine care.

This measles outbreak, in 1989-1990, was a catalyst for many changes in the Texas Department of Health (TDH). Prior to 1990, Texas did not have a division of the Department of Health that was solely dedicated to the delivery of immunizations. Funds were divided among multiple departments each handling a part of the Immunization Project under the direction of the Communicable Disease Division of TDH. In 1988, $13,887,100 in State funds were used to fund the Immunization Project in Texas. In 1992, the newly formed Immunization Division, within the Department of Health, created, consolidated, and/or expanded programs to increase vaccination rates. (TDH, unpublished).

In 1993, the "Shots Across Texas" program was initiated to spread the word about the importance of immunizing children. Also in 1993, the Immunization Division partnered with the Women's, Infant's, and Children's (WIC) program to provide immunizations to clients and their children during regularly scheduled WIC visits. To encourage private physicians to administer vaccines to Medicaid participants, a $3 per dose payment to providers was initiated by the TDH in 1993. Between September 1993 and August 1994, the number of physicians who requested vaccines from TDH increased by 24%. (TDH, unpublished).

The level of State funding was increased through the passage of 1993's Senate Bill 266. Beginning in 1994, an additional $18 million annually was added to the State's immunization budget. The State hoped to increase immunization rates through the purchase of increased vaccine supplies, infrastructure buildup and education. (TDH, unpublished).

Texas Health Steps is a program that provides preventive and primary health and dental care to Medicaid children. In 1994, this program was expanded to all Texas counties and developed an outreach tracking system. A portion of the Immunization Department's budget is used to provide vaccines to this program. (TDH, unpublished).

Currently, Texas funds its immunization program through several different funding sources: 25% of the budget comes from the State's General Revenue funds, 15% through Chapter 317, which pays for infrastructure costs, and 60% is from Federal funding through a program called Vaccines for Children (VFC). (TDH, unpublished). The Federal Government provides a block grant to each state through the VFC program. The State budget increase in 1994 supported the purchase of increased vaccine supplies, infrastructure buildup, and education. (TDH, unpublished).

METHODS

Cost-benefit analysis (CBA) gives decision-makers a method for analyzing public health programs. "It provides the most comprehensive consideration of the costs and benefits of intervention programs." (CDC, 1996). CBA includes all costs and benefits of a program to identify where the largest societal good is produced. Because CBA is founded in welfare economics, the results are based on which outcome generates the most benefit for society. CBA is the recommended type of economic analysis when priorities must be set on options within resource constraints. All health outcomes are evaluated and a dollar value is placed on the total program outcomes. CBA is the only type of economic analysis that allows comparison between health and non-health programs in terms of economic resources. Because the results are expressed in 'net dollars', different types and sizes of programs can be compared.

The Battelle (1994) and White et al. (1985) studies both used total benefit and cost estimates to calculate their benefit/cost ratios. While this would be appropriate if the costs and benefits of each vaccination provided remained the same, it is unlikely that such is the case. Indeed, it is likely that the additional benefit generated from each vaccination given would decrease as more children are immunized. As Texas reaches a level of herd immunity, the benefit of immunizing more children becomes smaller. Conversely, it is likely that the cost of administering additional vaccinations would increase, as more resources would have to be expended to find and vaccinate additional children. Therefore, it would not be in society's best interest to achieve a 100% vaccination rate because the cost of vaccinating the last child would almost certainly exceed any benefit from doing so.

A more appropriate method to analyze the cost and benefit data is to use marginal analysis to determine the efficient immunization rate. Figure 1 examines the marginal costs and marginal benefits of immunizing an additional 1% off Texas' children. The price is increasing on the Y-axis and the change in the percentage of children immunized is increasing on the X-axis. The upward sloping line represents marginal costs (MC). Because additional resources are required to immunize additional children, MC is increasing. In this context, the MCs of immunizing children in densely populated areas are low. The same resources could capture a larger population. A clinic located in downtown Fort Worth could serve a large number of people, while setting up a clinic in a rural West Texas town would require additional resources and serve a smaller population. The downward sloping line represents marginal benefits (MB). The law of diminishing marginal returns explains the reason for the MB line's downward slope. This law states that each additional child immunized provides smaller amounts of benefit to society in terms of the number of cases prevented. Once a level of herd immunity is reached, the additional benefit gained by immunizing another child is close to zero.

The goal of any program should be to optimize the use of its resources. In the case of the Public Health Department, this refers to its funding, State and Federal. In economic terms, the optimal size of a program refers to the point where marginal benefit and marginal cost are equal. In Figure 1, this is the intersection point of the lines. Given that MBs are decreasing and MCs are increasing as each additional immunization is administered, MC and MB eventually are equal. Each successive, incremental increase in immunization rate generates smaller and smaller additions to total benefit. This is represented by the decreasing size of the slope of the MB line. The term 'flat-of-the-curve' is used to describe the part of the marginal benefits curve where additional resources used generate little additional benefit. Producing vaccinations to the point where there is little additional benefit but high additional cost is not efficient. (Henderson, 1999). This paper looks at where the flat-of-the-curve would fall in relation to measles vaccination rates and disease rates.

In this cost benefit analysis, the costs and benefits of increasing the percent of 2-year-olds immunized from 70% to 80% to 90% is studied. All outcomes are expressed in monetary terms to allow costs and benefits to be compared directly. To determine the costs associated with the vaccination program, the Immunization Division's state funding and the cost of adverse reactions to the vaccine is used. The Immunization Division receives a fixed amount from the state on a biennium basis to support its activities. It is assumed the level of Federal funding remained consistent throughout the 1990s. This paper examines Texas' immunization program during this time period. The benefits of avoiding the disease include physician and hospital visits saved and deaths avoided with the costs of a loss of productive life years.

The following formula is used to calculate the benefit to cost ratio:

Benefit/Cost Ratio:

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{Total disease costs without vaccine} - \text{Total disease costs with vaccine}}{\text{Total vaccine associated costs (including vaccine and vaccine-associated vaccine reaction costs)}}$$

The societal perspective was used. Society is responsible for the costs and consequences of the vaccination program. The benefits of having children vaccinated extend to the entire population. The use of this broad perspective enables public health departments to maximize the efficiency of health care spending for the entire population. (CDC, 1996) The cost and benefit calculations from the Battelle (1994) study were used for the 1992 figures in Table 1. The cost estimates for the following years were inflated using the Consumer Price Index for Medical Care and Physician Services, as appropriate.

The costs and benefits associated with a change in the percentage of children immunized for the years 1963, 1990-1994, and 1996 were compared using marginal analysis. This is shown in Figure 1. The downward sloping line indicates diminishing marginal returns for each incremental improvement in the percent of children immunized.

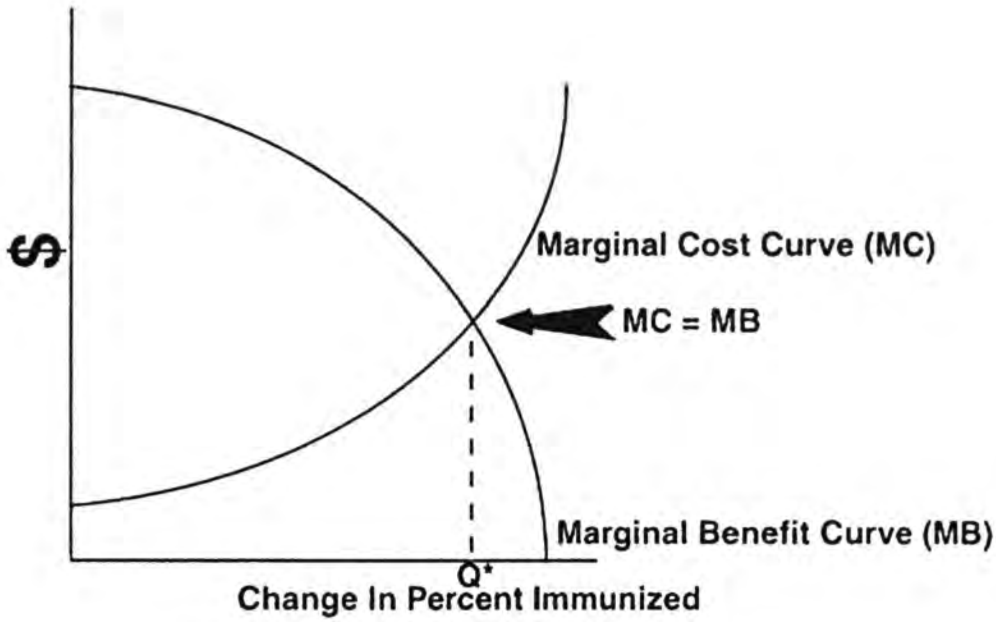

Figure 1. The marginal cost curve represents the additional cost of increasing the percent of children immunized by 1%. The marginal benefit curve represents the change in the benefit (in dollars) for each measles case prevented by immunizing an additional 1% of children. Q* is the optimal point where MC = MB.

Estimating Costs

The costs of the measles vaccination program include the Immunization Division's state budget and the vaccine associated adverse reaction costs. As mentioned previously, the measles outbreak of 1989-1990 was the driving force behind the changes in Texas' immunization practices. The number of cases of other vaccine preventable diseases has not changed dramatically compared with measles. This is why the entire Immunization Division's state budget is used in the calculating the direct costs.

Table 1 presents the Immunization Division's state budget for 1992, 1993, 1994, and 1996. After the passage of Senate Bill 266, funding increased to from 20.15 million in 1992 and 1993 to 38.1 million and 39.4 million in 1994 and 1996, respectively. The year 1995 has been omitted from the paper because the immunization rate for this year remains unpublished by the CDC.

The probabilities and assumptions for care for the vaccine related reaction costs are listed in Table 2. Adverse reactions can be categorized as minor or major. Major reactions include febrile seizures, thrombocytopenic purpura and anaphylaxis. The probability of occurrence varies from 1/10 for a minor reaction to 1/100,000 for an anaphylactic reaction. Each reaction may require a physician office visit and/or a hospital visit, depending on the severity of the reaction. The major reactions require the child's caregiver to spend from 1-3 days at home. Thrombocytopenic purpura is the only reaction that could be fatal, this occurs in 3% of the cases.

Table 1

Cost and Benefit Estimates

	1992	1993	1994	1996
Prevention of Measles:				
Immunization Dept's Budget	$20.15 million	$20.15 million	$38.1 million	$39.4 million
Texas' preschool pop.	1,390,054	1,438,279	1,486,504	1,582,955
Preschool Pop. Served by TDH	556,021	575,311	594,601	633,182
General physician visit, average cost	$45	47.50	50.43	53.73
Telephone consult	$9.11	9.62	10.21	10.88
Vaccine Reactions:				
Thrombocytopenic Purpura	$6,293	6,667	6,985	7,554
Febrile seizures, hospital costs	$3,461	3,667	3,842	4,155
Febrile seizures, ER costs	$401.39	425.25	445.52	481.84
Anaphylaxis	$2,832	3,000	3,143	3,399
Measles:				
Ambulatory Visit:				
With complication	$96.44	101.82	108.10	115.18
Uncomplicated case	$84.88	89.61	95.14	101.37
Hospital costs:				
Uncomplicated case	$3,619	3,834	4,017	4,344
Measles Encephalitis	$15,969	16,918	17,724	19,169
Encephalitis with residual damage, hospital costs	$16,205	17,168	17,987	19,453
Encephalitis with residual damage, long term care costs (annual)	$21,980 for 50 years	23,286 for 50 years	24,396 for 50 years	26,385 for 50 years
Measles pneumonia	$10,384	11,001	11,526	12,465
Measles otitis	$3,461	3,667	3,842	4,155
Measles SSPE	$6,136	6,501	6,811	7,366
Deaths (Probability of 3/1,000)	$23,582 for 47 years	24,984 for 47 years	26,175 for 47 years	28,308 for 47 years

Note. 1992 cost data obtained from Battelle Medical Technology Assessment and Policy Research Program. A cost benefit analysis of the measles-mumps-rubella (MMR) vaccine. 1994. Arlington, Virginia. Budget information from TDH's Budget Office in Austin, Texas. Population data from US Census data.

The physician visit, physician office telephone consult and hospitalization costs for vaccine related reactions are listed in Table 1. The 1992 estimates were taken from the Battelle (1994) study. All costs are national averages. Febrile seizures may only require a visit to the emergency room with an average cost of $401.39 or may require a hospital stay with an average cost of $3,461. The 1992 cost estimates are then deflated for the years 1993, 1994 and 1996 using the CPI for medical care and physician services, as appropriate.

Table 2

Vaccine Adverse Reactions: Probabilities and Assumptions for Care

	Minor Reactions	Major Reactions		
		Febrile Seizures	Thrombo-Cytopenic Purpura	Anaphylaxis
Probability of Occurrence	10%	1/1,000	3/100,000	1/100,000
Medical Care:				
Telephone consultation	20% (of those with reaction)			
Office visit	5% (of those with reaction)			
Probability of care	0%	100% - 1.0 E.R Visit	100%	100%
Probability of hospitalization	0%	10%	40%	100%
Days of hospitalization	N/A	3.3	4.5	1.9
Post-hospital physician visits	N/A	0	1.0	1.5
Case fatality rate	0%	0%	3%	0%
Days of home care	N/A	2.0	3.0	1.0

Note. This information was adapted from the Battelle Medical Technology Assessment and Policy Research Program. A cost benefit analysis of the measles-mumps-rubella (MMR) vaccine. 1994. Arlington, Virginia.

Estimating Benefits

The benefits of a vaccination program include the total disease costs with and without the vaccine. The costs avoided from children contracting measles are the benefits of a vaccination program. A child who has contracted measles may have no complications, minor complications such as diarrhea, or major complications. The major complications include otitis media, pneumonia, encephalitis with or without residual effects, or SSPE. Death occurs in approximately 3/1,000 cases. The most common complications are minor, occurring in approximately 10% of the measles cases. The probabilities of occurrence and assumptions for care are found in Table 3. Encephalitis, which only occurs in 1/1,000 cases, can have long lasting effects. In 25% of the encephalitis cases, permanent disabilities can occur. This not only requires immediate hospitalization, but also, long term care costs. In 1992 dollars, average health costs associated with such a case are $21,980 for the next 50 years. Hospitalization costs for measles encephalitis are the highest among the measles related complications. This is because it requires the longest hospital stay, even when there is no residual damage.

The physician visit and hospital costs for measles complications are found in Table 1. The physician visit costs are higher for disease related complications compared with vaccine related reaction costs. This is because the disease related complications require more office time by the physician due to their more serious nature. Average hospital costs range from $3,461 for treating measles otitis to $16,205 in the case of encephalitis with residual damage. The 1992 cost estimates were inflated for the years 1993, 1994 and

1996 using the CPI for medical care and physician services, as appropriate. To calculate the present value of the long term care costs to treat encephalitis with residual damage, the following formula was used: $PV = F [1/r - 1/(r (1 + r)^n)]$ where PV is the present value of the stream of benefits, F is the future annual value, r is the discount rate, and n is the years of constant stream. The future annual value was calculated using the Discount and Annuitization Tables in Prevention Effectiveness. (CDC, 1996). A three-percent discount rate was used.

With the growth of managed care in Texas over the last several years, the hospital cost figures may have changed. The number of hospitalized cases may need to be adjusted for this same reason. These numbers are difficult to obtain. The conservative figures from the Battelle (1994) study were used.

Measles is the most contagious of the vaccine preventable diseases. It is predicted that without a vaccination program 90% of the preschool population will acquire measles compared with an incidence rate of 5% with the vaccination program in place. The vaccine licensed and in use since 1963, protects approximately 95% of those who receive it. (National Vaccine Advisory Committee, 1991). Transmissions rate of 90% and higher were found prior to 1963. (White et al., 1985). These percentages would change once a level of herd immunity was reached and the chances of a child contracting measles becomes close to zero. For comparative purposes, a transmission rate of 90% without a vaccination program and a 5% transmission rate with a vaccination program are used in this paper.

Population data was obtained from U.S. Census data for the years 1992 and 1996. Estimates were made for 1993 and 1994. The 1995 statistics were omitted because the immunization rates were unpublished by the CDC. TDH reports they serve 40% of the population. Literature suggests the CDC estimate this figure at 50%. (White et al., 1985).

The death rate for measles varies from 1 to 3 per 1,000 cases. (Battelle, 1994). The higher death rate probability is used because this is associated with a younger population. This paper examines the immunization status of 2 year-olds. The benefits associated with death of a young child are those additional years of normal productive. Forty-seven years is the period between 18 and 65 years of age, the normal adult work-span. In 1992 dollars, the cost to society of a child's death was $23,582 annually for 47 years. The figure was obtained from the Productivity Loss Tables in Prevention Effectiveness. (CDC, 1996). The present value of the stream of benefits from preventing a death is calculated using the present value formula mentioned above. The future annual value was calculated using the same table from Prevention Effectiveness. (CDC, 1996). This figure was inflated for future years using the CPI. Table 1 shows the figures for future years.

In determining costs and benefits of the vaccination program, the value of a home care day or lost workday for women is $76 in 1992. The value of a lost workday for a woman was used because women are the primary caregivers for children. (Battelle, 1994). The 1992 figure was then inflated using the Discount and Annuitization Table in Prevention Effectiveness. (CDC, 1996). A three-percent discount rate was used to calculate years 1993, 1994 and 1996.

Table 3

Measles: Assumptions for Care

	Uncomplicated Case with or without Diarrhea	Otitis	Pneumonia	Encephalitis	SSPE
Days of Home Care (if no hospitalization)	3.5	4.0	4.5	5.0	--
Physician visits (if no hospitalization)	33% of non-vaccinated: 1 visit	75%: 1.5 visits	100%: 1.75 visits	100%: 2.0 visits	--
Days of hospitalization	3.9	4.0	6.3	10.2 If residual damage: 19.3	4.5
No. of Physician visits post-hospital care	2.0	0.66	1.8	4.0	10.0
Days of home care (post-hospital)	1.0	1.5	3.5	7.0	30.0
Probability of Occurrence	10%	8%	6%	1/1000 25% with residual effects	1/100,000

Note. This information adapted from the Battelle Medical Technology Assessment and Policy Research Program. A cost benefit analysis of the measles-mumps-rubella (MMR) vaccine. 1994. Arlington, Virginia.

RESULTS

CBA and marginal analysis were used to evaluate the data provided in Tables 1-4. The benefit/cost ratios, found in Table 5, show ratios between 17:1 to 30:1for Texas' measles vaccination program. This coincides with previous studies mentioned in the Background section of this paper. White et al. (1985) calculated a benefit/cost ratio of 14:1 and Battelle (1994) calculated a benefit/cost ratio of 17.2:1 for measles. However, these benefit/cost ratios only provide information as to whether the benefits of the entire program outweigh the costs. Such an analysis provides no evidence as to the appropriate scale of the program. In this regard, a marginal analysis can be helpful.

The data in Table 4 can be used to perform an incremental analysis similar to the type of analysis explained in Figure 1. Moving from an immunization rate of 0% in 1963, when the vaccination was first licensed for use, to a rate of 75.5% in 1990, generates tremendous 'bang for the buck' for the State in terms of marginal benefit per dollar spent to immunize 75.5% of the population at the age of 2. This is where MB exceeds MC by the largest amount. The approximately $20 million spent per year in 1990 dollars was used to achieve an immunization rate of 75.5%. Further increases in immunization rates yield smaller and smaller amounts of marginal benefits in terms of decreases in measles cases. At approximately an 81% immunization rate, case rates are less than 100. The curve then flattens out at an immunization rate greater than 81%. This means that after 1993, on the margin, additional gains in immunization status among 2-year-olds provide little to no additional benefit to the State of Texas in terms of decreased incidence of measles. This finding is strong evidence that the Texas' measles vaccination program is on the flat-of-the-curve. That is, it appears that the $18 million of State budget that was used to increase the State's 2-year-old immunization rate from 81% to 89% brought little extra benefit.

Table 4

Reported Cases and Immunization Rates

	1990	1991	1992	1993	1994	1995	1996
MCV Immunization rates for 2-year-olds @ 95% CI	75.5% (73.1-77.9)	75.8% (72.9-78.7)	77.5% (74.8-80.2)	80.8% (79.6-82.0)	83.3% (81.9-84.7)	*	89.0% (+/- 2.3)
Number of Reported Cases	4,409	294	1,097	10	17	14	49

Note. * Indicates the data was not published. Immunization rates were obtained from the 1998 Texas Retrospective Survey and the National Immunization Survey. The number of reported cases was obtained from TDH unpublished raw data.

Table 5

Benefit/Cost Analysis

	1992	1993	1994	1996
Benefits	$562,363,253.50	$616,744,898.20	$662,482,434.10	$758,534,940.00
Cost	$20,297,345.57	$20,296,128.99	$38,257,569.27	$39,579,823.69
B/C Ratio	27:1	30:1	17:1	19:1

DISCUSSION AND CONCLUSIONS

This paper supports previous findings that a measles vaccination program is beneficial. The disease can spread easily and be very expensive to treat. Introduction of the vaccine has saved countless lives and health care dollars. Measles cases have decreased by 95% since 1963. However, the question this paper addresses is: What is the optimal immunization level for Texas?

During the years 1990-1992, the number of measles cases was high. This was due to the statewide outbreak in 1990 and two smaller outbreaks in 1991 and 1992. It is believed that the size of the outbreak was, in part, due to the low immunization rate of the State. Since1993, the number of cases has remained low. The marginal analysis above provides strong evidence that the additional $18 million spent annually since 1994 has not generated additional benefits, but has only increased the total cost of this program.

There are two possible reasons for the positive changes in immunization rates and reported cases that began in 1993. First, the initial outbreak of 1989-1990 caused the State to recognize measles, a vaccine preventable disease, as a serious health issue. The Public Health Department then consolidated the immunization component into its own division, the Immunization Division. This more focused approach to immunizations appears to have had a dramatic positive impact prior to additions in funding by the State.

Second, the outbreaks seem to have increased the publics' awareness of the seriousness of this disease. A 1996 published study found the highest up-to-date immunization levels among Hispanics, just edging ahead of Anglo children. The authors of this study believed that recent measles epidemic in 1992, which disproportionately affected South Texas, may have contributed to increased awareness of vaccine preventable disease among Hispanics. (Simpson and Suarez, 1996).

TDH's policy of providing immunizations to anyone includes non-residents. (TDH, unpublished). The large network of public health clinics is able to serve the high immigrant population. The CDC reports that the transmission of indigenous measles stopped in the fall of 1993. However, importation of the virus resulted in moderate measles outbreaks in 1994 among groups that refused vaccination. (Battelle, 1996). In 1996, people traveling to the U.S. from other countries imported 47 cases to the U.S. In addition, at the start of 1997, all of the U.S. measles cases were imported. (TDH, unpublished). The TDH's vaccination of the immigrant population seems to be the key to decreasing the number of measles cases.

Further economic analysis is required to determine the most efficient level of measles vaccinations. This paper hints that this level may be between 80.8% and 89% for Texas, but,what is the efficient immunization level for each county in Texas. Border counties may require higher immunization levels than rural Texas communities. This type of evaluation would require data on a county level in regards to costs, immunization rates and disease rates. The State of Texas varies greatly as far as demographics. What might be efficient for urban or border areas may not be efficient for rural communities.

The inefficient overuse of State funds for immunizations takes away scarce State resources, which could be used, for education, environmental cleanup or other public health projects. Public Health Departments need to incorporate marginal analysis into their decision making process so that these scarce resources can be allocated in the most efficient manner possible.

Conducting future immunization studies in Texas requires accurate data collection. Currently, this may not be possible. Texas has no routine system to determine immunization levels in preschoolers. Retrospective surveys assess whether 5-year-olds entering school have received recommended immunizations prior to their second birthday. This data is 3 years old at that time. (Simpson and Suarez, 1996). Texas is addressing this problem through the implementation of 'Immtrac', the State's vaccination reporting system for public and private providers. It requires healthcare providers, who administer vaccines to children, to report those immunizations to Immtrac, after securing consent of the parent, guardian, or managing conservator. (TDH, unpublished). In the future, data on immunization rates may be more accurate.

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