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Implementation costs of a multi-component program to increase human papillomavirus (HPV) vaccination in a network of pediatric clinics

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INTRODUCTION

An estimated 79 million Americans are infected with the human papillomavirus (HPV). An additional 14 million people are infected each year, and most sexually active people will contract HPV at some point in their life.[1] Every year there are over 33,000 cancers caused by HPV, most commonly cervical cancer in women and oropharyngeal cancers in men.[2]

In 2006, the Food and Drug Administration (FDA) approved a vaccine that was subsequently recommended for routine vaccination by the Advisory Committee for Immunization Practices (ACIP) for adolescent girls and later boys at ages 11 and 12 years. Vaccination at this age is recommended because the immune response is stronger at younger ages and because the vaccine should be administered before the initiation of sexual activity and exposure to HPV. It is also recommended for females ages 13-26 and males ages 13-21 not previously vaccinated.[3,4] Awareness of the vaccine has increased since its introduction to the market. However, as of 2017, 39% of adolescent males and females were up to date with the vaccine series by age 13 and 49% of 13- to 17-year-olds were up to date compared to the 80% completion goal established by Healthy People 2020.[5,6]

Missed clinical opportunities are reported as the primary factor for not achieving higher rates of HPV vaccination.[7] Parents have indicated that the most important determinants of having their child vaccinated are having their healthcare provider recommend it, talking with a doctor, having time to discuss it, and visiting their healthcare provider in the past year.[8–13] Studies have corroborated this finding by showing that receiving a strong recommendation from their healthcare provider was the most important factor in parents' decision to vaccinate their child.[14,15] Parents' lack of information has been cited as a key barrier, and perceived satisfaction in the quality of information they receive is associated with uptake of the vaccine.[16–18]

Researchers at the University of Texas Health Science Center at Houston (UTHealth) and Baylor College of Medicine (BCM) in collaboration with Texas Children's Pediatrics (TCP) implemented evidence-based strategies to increase HPV vaccination rates in the Houston, Texas area. This multicomponent program consisted of provider assessment and feedback, provider reminders, and provider education components to increase provider recommendation of the vaccine, and parent education and reminders to provide quality information about HPV, HPV vaccination, and vaccination recommendations.

The purpose of this analysis was to examine costs, from the clinic/network perspective, associated with program implementation in a large pediatric clinic network with a sensitivity analysis examining effects of varying program implementation. As providers and healthcare organizations consider vaccination initiatives, it is important for decision makers to understand costs associated with implementing and recruiting patients/guardians for various components of these programs in their respective organizations.

METHODS

Study Description

This prospective cost analysis was conducted alongside the delivery of a multicomponent program to increase HPV vaccination in a network of pediatric clinics in a 5-county area around Houston from October 2015 through February 2018. The Adolescent Vaccination Project (AVP) consisted of four sequentially implemented components: assessment and feedback, provider education, provider/parent reminders, and parent education.

The TCP network includes 51 pediatric primary care clinics affiliated with Texas Children's Hospital and serves approximately 20% of the greater Houston metropolitan area pediatric population with over 200 physicians and 800 clinical staff. The average clinic has 19 clinical staff including physicians, nurse practitioners, nurses, and medical assistants. Over 152,000 unique patients between the ages of 11 and 17 were eligible to receive the HPV vaccine during the study period.

Immunization champions serving as liaisons between researchers and their respective clinic distributed tailored assessment and feedback (A&F) reports highlighting individual physician and aggregate clinic vaccination rates. The reports allowed providers to compare their vaccination rates with other clinics as well as national goals. One year after A&F implementation, the provider education program was introduced to all clinical staff. We developed a one-hour online continuing education (CE) session based on a preliminary needs assessment to relay the most current information regarding HPV and HPV vaccination and provide best practices for communicating with parents addressing potential barriers to immunization. The final system-level program was an automated reminder system for both providers and parents. Providers received reminders through the electronic health record (EHR) indicating if a patient was due or

overdue for a dose of HPV vaccine. Parents received similar reminders through the network's patient portal.

In addition to system-level strategies, parents were recruited to participate in a parent education program based on clinic randomization. A mobile application (app) specific to TCP presented several modules describing HPV, HPV vaccine, testimonials from network providers and parents, and tools to schedule their next appointment and receive appointment reminders through alerts on their mobile device.

Cost Estimation

In 2018, we used micro-costing at the clinic level to estimate program fixed and variable costs. This detailed and time-intensive method provides the most precise estimate of actual costs compared to gross costing, which depends on the price of services provided in the healthcare market and which may not be available for new services.[19]

Fixed costs were incurred prior to service delivery. These comprised contract services from third-party vendors to 1) implement automated EHR vaccination reminders for providers and parents, and 2) produce a network-tailored mobile application to educate parents on HPV and HPV vaccination. Fixed costs also included training costs. Variable costs consisted of staff time, supplies, and recruitment necessary to implement each strategy. With the clinic as the primary unit of analysis, we estimated an average cost per clinic by distributing fixed costs evenly among all clinics. Because of variation in the number of providers at each clinic, variable average costs were weighted on clinic resource utilization.

Variable Cost

We calculated the cost of time spent by project staff, clinic staff, and parents receiving the program by multiplying an estimated per-minute rate measured in US dollars by their time spent implementing tasks or participating in the education programs. Project staff pay rates and time available for implementation of tasks were adjusted by accounting for fringe benefits and estimated productivity rates (Table 1). Previous studies have used an 85% productivity rate largely based on Urban et al (1990)[20]. Since mid-1990, the US has seen significant growth in the average annual labor productivity due to capital investments in information technology along with innovative work processes.[21] A more recent analysis by Burda et al. (2015) used the American Time Use Survey (ATUS) 2003-2012, where sample

respondents reported spending 7% of their time at work not working.[22] Hence, productivity was assumed as 93% in this analysis.

Project staff time was self-reported using logs measuring time spent training immunization champions, maintaining clinic staff rosters, producing quarterly A&F reports, and producing additional resources including fact sheets and champion binders.

Clinic staff per-minute rates were estimated by averaging actual pay rates from a sample of 120 clinical staff representing all job classifications. Time spent by clinical staff implementing the different strategies was collected in two ways. First, immunization champions reported the time spent distributing and discussing the A&F reports with their peers using time logs. Second, we captured time spent completing the online CE using system-generated completion reports and multiplying the participants estimated wage rate by the duration of the learning module.

Material costs were captured by multiplying the number of pages printed for the A&F reports, training materials, and additional resources by the cost per page and then adding additional supplies where appropriate. Postage costs were incurred with the first two quarterly A&F reports; however, subsequent reports were sent via TCP's inter-institutional mailroom at no cost to the project. Because the reminder and educational programs were delivered electronically, material costs associated with these strategies were not incurred.

Fixed Cost

Third-party vendors were contracted to program and implement provider and parent reminders in the EHR and produce the mobile APP for the parent education program. Contractors created a pediatric EHR wellness registry on which an algorithm was applied to inform providers on patient's HPV vaccination status and whether any doses of HPV vaccine were due. The same registry and algorithm were used to notify parents of their child's HPV vaccination status through the online patient portal. App developers designed, tested, launched, and maintained the network-specific parent education program on multiple mobile platforms.

Parents were required to complete an online survey to participate in the parent education component. This contact method generated recruitment costs of only parents eligible to receive the education component based on the clinic they identified with. Because this analysis is from the clinic/network perspective, parent time spent engaging in the recruitment process was excluded. However, monetary incentives received via an electronic gift card were included as their cost was born by the

program to attract participants. Also included were time and mileage of project staff incurred inviting parents to the program and visiting clinics to actively recruit participants at clinics randomized to receive the parent education component.

RESULTS

Program Implementation

Total program implementation costs between October 2015 and February 2018 totaled $157,534. The average cost per clinic (n=51) was $4749 weighted on clinic size and staff participation. In aggregate, the average cost per HPV vaccination-eligible adolescent was about $1.

Quarterly A&F reports were delivered to 6 pilot clinics beginning in February 2016 with full rollout to all clinics in May 2016 at a total cost of $35,334 and average cost of $786 per clinic (Table 2). Costs were categorized by personnel time spent producing and distributing the A&F reports, material costs, and binders provided to keep each respective clinic's reports. Time spent by project and clinic staff producing and distributing the A&F reports totaled $21,611 and $7935, respectively. The cost of the packets was $4683 and $1105 for the champion binders totaling $5788 in material costs. Average costs per clinic were $660 and $125 for personnel time and materials, respectively. Time costs represented 84% of the total A&F implementation cost with 73% of that representing the time spent extracting vaccination rates from the EHR composing the reports, and compiling them into packets for each of the 51 clinics.

A total of 221 clinical staff completed the 1-hour online course at a total cost of $10,225 in personal time and an average of $368 per clinic (Table 2). The largest share, $6699 (66%), resulted from 55 physicians (25%) completing the course and having the highest wage rate. Medical assistants (MAs) constituted the largest share of participants (92, or 42%) at a cost of $1516 (15%). Nurses (49, or 22%) also completed the course costing $1306 (13%). The remainder of participants were made up of a combination of nurse practitioners, practice managers, social workers, and other clinical support staff.

Healthcare providers and parents received automated reminders through the EHR at a cost of $42,000 for third-party contracted services (Table 2). The total cost was not dependent on clinic size and was divided equally among all 51 clinics for an average cost of $824.

The parent education component cost totaled $55,228, representing combined contracted services for producing the tailored mobile app (Table

2). Fifty-six of the 141 parents intended for treatment utilized the mobile education application and averaged less than a minute per parent directed to the app. The average contract cost was $2126 per clinic receiving the app. Including the parent recruitment cost resulted in a total cost of $63,286 at an average of $2540 per clinic.

Champion Training and Parent Recruitment

Prior to program rollouts, TCP champions, 2 from each clinic, participated in a series of training webinars, 1 for the pilot clinics and 3 for all clinics, hosted by UTHealth project staff. Each webinar was approximately 30 minutes and with a total training cost of $6689 (Table 2). A total of 223 TCP staff identified as champions participated in at least 1 of 4 webinars at a time cost of $5907, an average cost of $115 per clinic. Due to champion turnover throughout the study period, an average of 2 webinars were attended by each participant. The cost of hosting and administering the training sessions was $782.

Additionally, variable recruitment costs were incurred to introduce the parent education component. Ninety-eight parents were recruited through the online survey at a total cost of $8058 with the largest individual share coming from incentives paid to participants ($3525, or 44%). The remaining $4533 (56%) resulted from recruitment activities including project staff time and traveling to clinics, and providing recruitment printed materials.

Sensitivity Analysis

There were 3 primary sources of variability in measured costs of program implementation: variation in TCP champion participation and wage rates, number of parents participating in the parent education, and the methods for recruiting participants in the parent education component. A sensitivity analysis was conducted using total average costs to demonstrate how costs vary with different TCP staff and parent participation.

A&F implementation costs were estimated under different scenarios depending on variation in TCP wage rates under the observed participation level. The least costly and costliest scenarios assume observed champion participation at the lowest and highest TCP wage rates--medical assistants and physicians--that resulted in cost estimates of $633 and $807 per clinic, respectively. These were compared to observed wage rates, or base case, of $786 per clinic. Assuming the least costly and costliest scenarios, total program implementation cost ranges between $151,413 and $162,747 with

differences from the observed $157,534 of -$6121 and +$5213, respectively.

The parent component targeted 26 clinics randomly assigned to receive the parent education component from among the total 51 clinics. We then used simulation to scale up the intervention to all clinics and estimate the effect on the total average cost of the parent education. Observed weighted average recruitment costs were imputed for the additional clinics, resulting in an average variable cost of $360 per clinic. Fixed costs were distributed across all 51 clinics, yielding an assumed average fixed cost of $1082 per clinic. The total average cost of expanding the parent component to all clinics declined from the observed $2540 to an estimated $1443 due to broader distribution of fixed costs. Assuming average observed cost across the additional 25 clinics, total implementation cost increases by $10,350 to $167,884.

It is assumed recruitment costs through the parent survey would be incurred under normal implementation. The sensitivity analysis was expanded to consider alternate scenarios, assuming no survey was used for recruitment as a minimum, the observed costs as the maximum, and the midpoint to estimate a combination or alternate recruitment strategy. Incentive cost totaled $3525. Removing this component resulted a 44% reduction in recruitment cost to $4533 ($126 per clinic from $414). Assuming a midpoint cost savings of $1763, recruitment costs are estimated at $6295 ($270 per clinic). Different recruitment strategies may have a significant effect on recruitment costs; however, in this case, total implementation cost was reduced only about 3% to $154,009 at the minimum and only about 1% to $155,771 at the assumed midpoint.

DISCUSSION

Implementation costs were estimated for a multicomponent strategy to increase HPV vaccination rates in a large pediatric clinic network. A&F, provider education, provider/parent reminders, and parent education components were implemented at total average costs of $786, $368, $824, and $2126, respectively, per clinic. The AVP program was delivered at a total cost of $157,534, or $4749 per clinic. Sixty-six percent ($103,917) of the total costs were fixed, including contracted services to produce vaccination reminders to providers and parents and the tailored parent education mobile app and training costs. The variable costs included materials and personal time spent generating and distributing A&F reports and time spent participating in the provider education program (29%, $45,559) and recruiting parents to the AVP (5%, $8058). Future programs

may forgo this recruitment step with the risk of drawing ineligible participants and attracting fewer participants.

Though excluded from this clinic/network perspective, we estimated the time spent by parents engaging with the mobile app and recruitment activities and the cost associated with that time. Parents spent an average of about 17 minutes, mostly completing the survey. The cost of this time totaled $599 completing the recruitment survey and $51 utilizing the education app. We found this cost to be minimal, only accounting for about 0.4% of the total program cost.

The analysis utilizes the network/clinic as the unit of analysis to inform administrators about the costs associated with implementing these system-level strategies. Previous studies examining costs of programs to increase HPV vaccination rates and cancer screening have focused on patients as the unit of analysis. A 2017 study compared 2 HPV vaccination intervention strategies for Hispanic parents of daughters aged 9 to 17 years old. The estimated per-participant cost was $88 for the print-based photo novella method and $108 for the iPad-based tailored interactive multimedia intervention.[23] The AVP program was delivered at an estimated $1 per HPV vaccine-eligible adolescent, highlighting the advantage of implementing in a large clinic network and targeting providers reaching substantially more eligible patients than other strategies. For example, over the course of this study, 155,000 HPV vaccination-eligible adolescents were seen in TCP clinics and 107,165 (69%) initiated the vaccine series. In 2017, about 58% of adolescents in Texas had received one or more dose of HPV vaccine while about 40% were up to date.[24] Though observed vaccine initiation during the study period does not meet the Healthy People 2020 goal of 80%, it considerably outpaces Texas rates.

Even though the observed AVP costs per patient are less than those of other intervention strategies, the sensitivity analysis shows that the level of participation and wage rates have an effect on overall cost to the clinic and network for implementing these strategies. Depending on who and how many participate in the A&F component, program costs can vary from $633 to $807 per clinic, compared to the observed $786. This results in a range of about $151,413 to $162,747 in total costs. Additionally, expanding the parent education component to all 51 clinics reduced the per-clinic average cost from $2540 to $1443. Because a large share of the total cost is fixed, the overall average cost per clinic is sensitive to the number of clinics and parents participating in the program though total program costs increase by $10,350 when expanding across all clinics.

This study has limitations. UTHealth personnel time costs were based on self-reported time, and TCP wage rates were based on a sample

of actual salaries across all job descriptions. It is also possible for providers to complete the education module outside of normal clinic hours, reducing clinic costs, and imposing a personal time cost on the provider. Wage information for parents was estimated based on census per-capita income of the individuals' zip code. Time spent by providers discussing HPV vaccination with patients was not observed and therefore omitted from the cost estimates.

CONCLUSION

While HPV vaccination has been shown to be a cost-effective way to prevent HPV-related cancers[25], the cost of strategies for increasing HPV vaccination have not been determined. Provider-based strategies including A&F, provider education, and reminders were implemented at costs of $35,334, $10,225, and $42,000, respectively, with a complimentary parent component introduced to a random sample of clinics costing $55,228. Additional training and recruitment costs equaled $6689 and $8058, respectively. Fixed costs represented the largest share (66%) of total costs, making the results sensitive to the number of participating clinics and parents (Figure 1). Future assessments should replicate the cost analysis under normal operating conditions with minimal to no external support. This research serves to inform implementation scientists and clinic and provider network decision-makers on the costs of implementing strategies for increasing HPV vaccination among adolescent patient populations.

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Table 1. Project Staff Wage Adjustment

Position	Base Work Hours per Year	Base Annual Salary ($)	Fringe Benefit Rate (1)	Salary and Fringe (2)	Salary per Minute (3)	Total Paid Time Off Hours (4)	Annual Hours at Work (5)	Annual Hours Available for Tasks (6)	Proportion of Paid Time Available for Tasks (7)	Adjusted Salary per Minute (8)
Project manager	2080	70,845	0.27	89,973	0.72	188	1892	1760	0.85	0.85
Project coordinator	2080	45,320	0.33	60,276	0.48	176	1904	1771	0.85	0.57
Database manager	2080	66,852	0.33	88,913	0.71	260	1820	1693	0.81	0.88
Graduate assistant	1040	20,000	0.26	25,200	0.40	40	1000	930	0.89	0.45

(1) Institution fringe benefit rates

(2) (Base Salary * Fringe Benefit Rate) + Base Annual Salary

(3) Per-minute rate of Base Annual Salary excluding fringe benefits. 100% based on 52 wk/y and 40 h/wk. 50% based on 52 wk/y and 20 h/wk. Intern is 10 wk/y and 40 h/wk.

(4) 100% employees calculated at 8 h/day and 50% employees calculated at 4 h/day.

(5) Work hours per Year - Total Paid Time Off Hours

(6) Annual Hours at work - (Annual Hours at Work * 0.07). Calculation based on 93% productivity rate based on Burda et al.[21]

(7) Annual Hours Available for Work / Work Hours per Year

(8) (Salary and Fringe / Annual Hours Available for Tasks) / 60

Table 2. Strategy Implementation Costs

Resource Input	Units	Variable Cost	Fixed Cost	Average Cost per Clinic[1]
Total Program Implementation		**$53,617**	**$103,917**	**$4749**
Assessment and Feedback (A&F)		**$35,334**	.	**$786**
Personal time (min)	34,381	$29,546	.	$660
UT project staff (min)	27,904	$21,611	.	$501
TCP clinic staff (min)	6477	$7935	.	$159
Materials		$5788	.	$125
A&F report packets (packets)	412	$4227	.	$95
Resource packets (packets)	51	$456	.	$9
Champion binders (binders)	51	$1105	.	$22
Provider Education		**$10,225**	.	**$368**
TCP staff time (min)	13,260	$10,225	.	$368
Provider Reminders		.	**$42,000**	**$824**
Contract services (services)		.	$42,000	$824
Parent Education		**$52**	**$55,228**	**$2126**
Mobile application (applications)		.	$55,228	$2126
Training		.	**$6689**	**$231**
Personal time		.	$6689	$231
UT project staff (min)	700	.	$782	$116
TCP clinic staff (min)	6092	.	$5907	$115
Recruitment		**$8058**	.	**$414**
UT project staff (min)	10,070	$3423	.	$101
Mileage (mi)	1224	$655	.	$8
Incentives (gift cards)	141	$3525	.	$288
Printed materials (pages)	2274	$455	.	$17

[1] Assessment and Feedback, Provider Education, and Provider/Parent Reminders were implemented in 51 clinics. Parent Education was implemented in 26 clinics.

Figure 1. Program Cost Distribution