Vaccine 37 (2019) 6180–6185

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Analysis of the profitability of adult vaccination in 13 private provider practices in the United States

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ARTICLE INFO

Article history:
Received 4 March 2019
Received in revised form 21 August 2019
Accepted 22 August 2019
Available online 5 September 2019

Keywords:
Economic analysis
Adult vaccination
Financial analysis
Barriers to vaccination

ABSTRACT

Vaccination coverage among adults remains low in the United States. Understanding the barriers to provision of adult vaccination is an important step to increasing vaccination coverage and improving public health. To better understand financial factors that may affect practice decisions about adult vaccination, this study sought to understand how costs compared with payments for adult vaccinations in a sample of U.S. physician practices. We recruited a convenience sample of 19 practices in nine states in 2017. We conducted a time-motion study to assess the time costs of vaccination activities and conducted a survey of practice managers to assess materials, management, and dose costs and payments for vaccination. We received complete cost and payment data from 13 of the 19 practices. We calculated annual income from vaccination services by comparing estimated costs with payments received for vaccine doses and vaccine administration. Median annual total income from vaccination services was $90,343 at family medicine practices (range: $3968–$249,628), $28,267 at internal medicine practices (−$32,659–$141,034) and $2886 at obstetrics and gynecology practices (−$73,451–$23,820). Adult vaccination was profitable at the median of our sample, but there is wide variation in profitability due to differences in costs and payment rates across practices. This study provides evidence on the financial viability of adult vaccination and supports actions for improving financial viability. These results can help inform practices' decisions whether to provide adult vaccines and contribute to keeping adults up-to-date with the recommended vaccination schedule.

1. Introduction

Vaccination is among the most successful and cost-effective public health interventions in terms of both preventing disease and being a reasonable and efficient use of health system resources [1,2]. In the February 2019 adult immunization schedule, a number of vaccinations were recommended for the general US adult population, including: an annual influenza vaccine, a one-time dose of tetanus-diphtheria-acellular pertussis vaccine (Tdap) coupled with a decennial tetanus-diphtheria (Td) booster, two different vaccines against pneumococcal disease[1], and a vaccine to prevent herpes zoster (or shingles) [4]. Beyond the general population of adults, a number of adult vaccination recommendations also address populations with additional indications for some vaccines, such as pregnant women, health care workers, and individuals with immunocompromising conditions [4].

Even with these recommendations, vaccination coverage among adults remains low in the United States [5,6]. In 2011, the National Vaccine Advisory Committee issued recommendations for improving adult vaccination coverage levels and identified financial impediments as one category of barriers to adult vaccina-

[1] At the June 2019 meeting of the ACIP, the recommendation for pneumococcal vaccinations among adults was changed to the following: "ACIP recommends PCV13 based on shared clinical decision making for adults 65 years or older who do not have an immunocompromising condition and who have not previously received PCV13. All adults 65 years or older should receive a dose of PPSV23".[3] CDC, ACIP. ACIP Recommendations, June 2019 Meeting Recommendations. 2019.

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https://doi.org/10.1016/j.vaccine.2019.08.056
0264-410X/

tion [7]. In 2016, the National Adult Immunization Plan established a goal of improving access to adult vaccines, including an objective to assess financial barriers to providing vaccinations by researching the total costs of providing vaccination services in a provider setting [8].

A number of studies have documented that physician practices feel they face financial challenges in providing adult vaccination, such as inadequate reimbursement, delays in receiving reimbursement, uncertainty in forecasting vaccine needs, and substantial expenses in acquiring and maintaining a vaccine stock. Practices noted that these challenges have made them consider stopping or limiting provision of vaccination services [9–12]. Given these financial concerns, there is a recognized need to develop a better understanding of the economics of vaccination [8]. Similar concerns were raised by pediatricians several years ago, leading to the development of a business case for provision of pediatric vaccination services (last revised in 2012). This business case supported the goal of achieving maximum vaccination coverage of children by assisting pediatric practices in receiving full payment for their direct and indirect costs of vaccinating patients including payments for overhead expenses [13]. A separate business case is needed for the provision of adult vaccination, because the adult vaccination schedule is complex with both age-based and risk-based recommendations [6]. While the volume of vaccinations given in adult practices is less than in pediatric practices, vaccinations remain an essential and recommended primary care service for adult patients. Our study seeks to assess how the costs of providing vaccinations compare with vaccination-related payments to understand the profitability and business case for physician practices to provide adult vaccination services.

2. Materials and methods

2.1. Data collection

Recruitment of practices for participation in the study was conducted in four cities each in a different state. Cities were selected based on the distribution of wages for medical professionals. Two cities were identified from the top tercile and two from the bottom tercile [14]. Using Google Maps, a web-based search of each city was conducted to identify potential family medicine (FM), internal medicine (IM), and obstetrician and gynecologist (OB-GYN) practices to recruit. Across the four cities, more than 250 practices were first contacted via a postal letter and a follow-up phone call. Practices were eligible for the study if the practice self-reported providing five or more vaccinations per week. Initial recruitment produced low response rates, particularly among OB-GYN practices. We then used the American College of Obstetricians and Gynecologists professional directory to identify additional OB-GYN practices. OB-GYN response rates remained low, so we recruited additional OB-GYN practices from an unrelated study that was already being conducted by two of the study co-authors. Our final convenience sample consisted of 19 practices from nine states. All but one of the FM and IM practices were from the same two cities. Each OB-GYN practice was from a different city. The sample included six FM practices, six IM practices, and seven OB-GYN practices. Appendix Table A1 presents summary information on the sample of practices including size, geography, and fraction of patients covered by Medicaid and Medicare.

The study consisted of three components: a management survey, a time-motion study, and a finance survey. Each component focused on collecting a different part of the cost or revenue data associated with vaccination services at the practices. We collected data from participating practices between March 2017 and October 2017. The study was intended to be conducted outside of influenza vaccination season (typically September–March), because the financial viability of adult vaccination during peak influenza vaccination season is more widely accepted given the lower cost of influenza vaccines relative to other adult vaccines and increased volume of vaccinations during that time [11]. However, because of delays in recruitment, one OB-GYN and one FM practice were observed during early influenza vaccination season in October 2017. Not all practices could provide data for all study components: the management survey was completed by 19 practices, the time-motion study was conducted in 16 practices, and the finance survey was completed by 16 practices. A total of 13 practices completed all three study components and were included in our analysis. Six of these 13 practices self-reported being part of two larger health systems that obtained negotiated prices for vaccines, other vaccination supplies (e.g., syringes), and private-payer payment rates.

The management survey and time-motion study were used to estimate the costs of providing vaccination and these results have been described in an earlier publication [15]. In the finance survey, practice finance staff were asked to provide the following information for each vaccine offered by the practice: purchase price per dose; number of doses purchased and used in the previous year (2016); payment amounts for vaccine doses and vaccine administration from each payer; and the percentage of patients at the practice covered by each payer. Among the practices that were part of a larger health system, this information was provided by an administrator from each of the two participating health systems. This study was reviewed by the RTI institutional review board and determined not to be human subjects research.

2.2. Analysis

Using data collected in the management survey, time-motion study, and the finance survey we estimated the revenue, costs, and income (i.e., revenue minus costs) to assess the profitability of providing adult vaccinations. All values are reported in 2017 U.S. dollars. Due to the small sample size, the results presentation focuses on median values.

2.2.1. Annual revenue

We calculated total payments across all payer types for the total number of adult vaccine doses and vaccine administrations in the past year. The calculation of the total annual number of adult vaccine doses in the past year was reported by practices in the finance survey and was adjusted for several factors, including: (1) the collection of data components outside of influenza vaccination season; (2) whether or not the practice reported data at the health system level; and (3) whether or not the practice was a FM practice serving both pediatric and adult patients,. Complete details on these adjustments are available in Appendix A.

In the finance survey, practices reported the percentage of their patients that were covered by different payers (i.e., Medicare, Medicaid, or specific private insurance). We assumed the percent of vaccine doses and administrations that were paid for by each payer type was equal to the percent of patients in the practice that were covered by each payer.

2.2.2. Annual costs

The time-motion study and management survey collected data on staff time and materials costs related to adult vaccination. The methodology and results on the cost estimates are described in detail in an earlier manuscript [15]. The earlier study presented weekly costs, so for this study we converted all costs to annual values (see Appendix A for details). In the present study, we added data on the purchase price per vaccine dose. Because it is a common question among practitioners, we conducted a preliminary

comparison of median purchase price per dose and median payment for the vaccine dose. Then to better compare estimated costs with revenues, we organized costs into two categories that correspond to the two types of payments received for vaccination services: vaccine dose costs and vaccine administration costs. We defined the vaccine dose cost as the sum of the purchase price per vaccine dose, any costs to forecast and purchase vaccines, and costs to store and manage inventory. We defined the vaccine administration cost as the sum of costs to review charts for vaccination and interface with the state immunization information system, counsel and vaccinate the patient, document vaccination, and bill and reconcile payments. All vaccination costs except dose purchase price were assumed to be the same across vaccine types.

2.2.3. Annual income

We computed the total annual income from vaccination for each practice by subtracting annual costs from annual revenue for the vaccines administered in the past year. We calculated total annual income and subtotal income associated with vaccine doses and with vaccine administrations. We also calculated income per vaccination by dividing total annual income by the number of vaccines they administered. We reported median income by practice type.

3. Results

Table 1 presents information on the practices in the final analysis sample, including 3 small practices and 10 larger practices. Geographically, the practices were in the southern and western regions of the United States. All practices had less than 30% Medicare patients and less than 20% Medicaid patients with most having 0% Medicare and Medicaid patients. All participating practices were in urban areas. Payer mix appears to be different across wage terciles. All practices in the high wage tercile had 0% Medicare and Medicaid patients, whereas three of four practices in the low wage tercile had 20% Medicare patients and 9% Medicaid patients.

The mean annual number of adult vaccine doses administered was 3267 in FM practices, 1506 in IM practices, and 1019 in OB-GYN practices (Table 2). Most vaccines administered were for influenza (50% in FM practices, 43% in IM practices, and 59% in OB-GYN practices) and tetanus-containing (Td or Tdap) vaccines (30% in FM practices, 45% in IM practices, and 26% in OB-GYN practices).

Table 3 presents median cost for time associated with the vaccine administration payment and payments for vaccine administration. Among FM and IM practices, the median administration payment was greater than median administration cost for all payer types. However, payments from Medicaid were substantially lower than those from private payers and Medicare. Among OB-GYN practices, costs for vaccine administration were substantially higher than payments received from Medicaid, approximately equal to payments received from Medicare, and lower than payments received from private payers.

Table 2
Median Number Adult Vaccines Administered Annually and Vaccine Mix, by Practice Type.

Vaccine Type[a]	FM[b] (n = 4)	IM (n = 4)	OB-GYN (n = 5)
Median Number of Adult Vaccines Administered Annually	3265 (563–5811)	1160 (257–3449)	640 (231–2270)
Influenza	50% (39–58%)	43% (39–46%)	59% (42–83%)
HPV	3% (0–5%)	2% (0–5%)	13% (0–32%)
Td	20% (0–61%)	30% (0–61%)	NA
Tdap	10% (0–29%)	15% (0–29%)	26% (13–51%)
PPSV23	5% (0–9%)	3% (0–5%)	NA
PCV13	7% (0–12%)	6% (0–12%)	NA
MCV	1% (0–3%)	1% (0–3%)	NA
Hep AB[c]	1% (0–4%)	NA	1% (0–7%)
MMR	1% (0–4%)	NA	NA
Zoster	1% (0–4%)	NA	NA

Notes:
Abbreviations: FM = Family Medicine; IM = Internal Medicine; OB-GYN = Obstetrics and Gynecology; HPV = Human Papillomavirus; Td = Tetanus and Diphtheria; Tdap = Tetanus, Diphtheria, and Pertussis; PPSV = Pneumococcal Polysaccharide Vaccine; PCV = Pneumococcal Conjugate Vaccine; MCV = Meningococcal Conjugate Vaccine; Hep AB = Hepatitis A and B; MMR = Measles, Mumps, and Rubella; NA = not applicable.
[a] Percentages across vaccine types within practice type may not add up to 100% due to rounding.
[b] Family practices, on average, administered an additional 1507 pediatric vaccines per year. The percentages listed for each vaccine are for adult vaccines only.
[c] Hepatitis A and B vaccines were only captured together due to reporting error.

Table 1
Practice Characteristics.

Practice ID	Practice size[a]	Census region[b]	Wage tercile[c]	% medicare[d]	% medicaid[d]
FM A[e]	Larger	West	High	0	0
FM B	Larger	West	High	0	0
FM C	Larger	South	Middle	19	14
FM D[e]	Larger	South	Low	28	9
IM A[e]	Larger	West	High	0	0
IM B[e]	Larger	West	High	0	0
IM C[e]	Small	South	Low	28	9
IM D[e]	Small	South	Low	28	9
OB-GYN A	Larger	South	Middle	0	0
OB-GYN B	Larger	South	High	0	0
OB-GYN C	Larger	West	Middle	2	20
OB-GYN D	Larger	South	Low	0	0
OB-GYN E	Small	West	High	0	0

Notes:
[a] Small = 1–2 physicians; larger = 3 + physicians.
[b] For census region definitions see https://www.census.gov/geo/reference/gtc/gtc_census_divreg.html.
[c] Wage terciles were determined by the distribution of wages for medical professionals (doctors, nurses, and physicians assistants) [14].
[d] Percentage of patients with Medicare and Medicaid were self-reported in the finance survey.
[e] Practices from two participating health systems that reported finance information for the group as a whole.

Table 3
Median Cost Associated with Vaccine Administration and Vaccine Administration Payments, by Practice Type and Payer.

	Number of Practices	Median Cost per Vaccination ($)[a]	Median Payment per Vaccine Administration					
			Medicare		Medicaid		Private Payer[b]	
			Number of Practices	Median ($)[a]	Number of Practices	Median ($)[a]	Number of Practices	Median ($)[a]
Total	13	13.36	6[c]	20.18	6[c]	13.56	13[c,d]	24.57
FM	4	3.94	3[c]	24.41	2[c]	13.56	4[c,d]	23.31
IM	4	4.14	2[c]	19.28	2[c]	13.81	4[c,d]	20.84
OB-GYN	5	21.35	1	21.07	2	8.90	5	28.12

Abbreviations: FM = Family Medicine; IM = Internal Medicine; OB-GYN = Obstetrics and Gynecology.
[a] All prices and payments are reported in 2017 U.S. dollars.
[b] Average payment for private insurers is calculated using a weighted average of private payers within each practice by patient share, and then a simple average across practices.
[c] One reported number covered all practices in the first participating larger health system (1 FP practice and 2 IM practices).
[d] One reported number covered all practices in the second participating larger health system (1 FP practice and 2 IM practices).

Table 4
Median Time Cost Associated with the Vaccine Dose Payment, Vaccine Price, and Vaccine Dose Payments, by Practice Type and Payer.

		Number of Practices	Median Price/Cost per Dose ($)[b]	Median Payment per Vaccine Dose[a]					
				Medicare		Medicaid		Private Payer[d]	
				Number of Practices	Median ($)[b]	Number of Practices	Median ($)[b]	Number of Practices	Median ($)[b]
Staff Time and Equipment	Total	13	2.43	NA	NA	NA	NA	NA	NA
	FM	4	1.11	NA	NA	NA	NA	NA	NA
	IM	4	2.14	NA	NA	NA	NA	NA	NA
	OB-GYN	5	6.54	NA	NA	NA	NA	NA	NA
Vaccine Dose	Hep A/B (Twinrix)[f]	2	96.60	0	NA	1	88.61	2	100.37
	HPV (9vHPV)	9[d]	187.10	0	NA	0	NA	9[d]	232.00
	HPV (4vHPV)	2	167.92	0	NA	0	NA	2	175.22
	Influenza (Fluarix Quadrivalent)	5[e]	14.25	4[e]	41.87	0	NA	6[e]	32.54
	Influenza (Flulaval)	3[e]	14.25	3[e]	41.87	3[e]	22.4	4[e]	30.01
	Influenza (Fluzone Quadrivalent)	3[e]	15.40	0	NA	0	NA	4[e]	47.06
	Influenza (Fluzone Quadrivalent No Preservative)	8[d,e]	16.26	4[e]	41.87	2	17.62	8[d,e]	21.54
	Influenza (Fluvirin)	1	9.15	1	17.14	1	14.62	1	16.34
	Influenza (Flucelvax)	1	14.68	0	NA	0	NA	1	20.19
	MCV (Menactra)	4[e]	89.00	0	NA	4[e]	150.35	4[e]	131.57
	MCV (Menveo)	6[d,e]	66.75	0	NA	3[e]	150.35	6[d,e]	133.49
	Men B (Bexsero)	3[e]	170.00	0	NA	3[e]	214.09	4[e]	179.83
	MMR (M-M-R-II)	2	64.48	0	NA	1	40.61	2	63.44
	PCV13 (Prevnar)	4[d]	112.00	0	NA	1	131.44	5[d]	193.40
	PPSV23 (Pneumovax)	5[d]	76.54	32	86.74	1	31.21	5[d]	97.86
	Tdap (Adacel)	4	38.43	0	NA	2	35.64	4	46.49
	Tdap (Boostrix)	6[d]	31.23	0	NA	1	39.10	6[d]	40.91
	Td (No Trade Name)	4[e]	31.00	0	NA	0	NA	4[e]	27.52
	Td (Tenivac)	8[d,e]	28.58	0	NA	0	NA	8[d,e]	26.42
	Varicella (Varivax)	4[d]	106.20	0	NA	1	85.56	5[d]	121.53
	Herpes Zoster (Zostavax)	2	202.54	0	NA	1	202.93	2	203.25

Notes:
Abbreviations: FM = Family Medicine; IM = Internal Medicine; OB-GYN = Obstetrics and Gynecology; HPV = Human Papillomavirus; Td = Tetanus and Diphtheria; Tdap = Tetanus, Diphtheria, and Pertussis; PPSV = Pneumococcal Polysaccharide Vaccine; PCV = Pneumococcal Conjugate Vaccine; MCV = Meningococcal Conjugate Vaccine; Hep AB = Hepatitis A and B; MMR = Measles, Mumps, and Rubella.
[a] Practices within two participating medical groups reported finance information for the group as a whole. Not all practices reported prices and payments for each vaccine and payer type.
[b] All prices and payments are reported in 2017 U.S. dollars.
[c] Average payment per dose for private payers is calculated using a weighted average of private payers within each practice by patient share, and then a simple average across practices.
[d] One reported number covered all practices in the first participating larger health system (1 FP practice and 2 IM practices).
[e] One reported number covered all practices in the second participating larger health system (1 FP practice and 2 IM practices).
[f] Hepatitis A and B vaccines were only captured together due to reporting error.
[g] Ranges are reported in Appendix Tables A1 and A2.

Table 4 presents median cost for time and equipment associated with the dose payment, vaccine dose price, and payments for vaccine dose. Payments for vaccine administration were similar across practice types with the exception of OB-GYN practices, which received a lower median payment from Medicaid and a higher median payment from private payers. Stratified by payer type, payments were greater than vaccine dose prices for all vaccines for Medicare (out of 5 vaccines paid for at participating practices), 9 vaccines for Medicaid (out of 14 vaccines paid for at participating practices), and 16 vaccines for private payers (out

Table 5
Median Practice Total Vaccine-Related Income Estimates, by Practice Type and Wage Tercile.

	Practice Type			Wage Tercile		
Counts, Vaccines, and Net-Revenue	FM (Range)	IM (Range)	OB-GYN (Range)	Low (Range)	Middle (Range)	High (Range)
N	4	4	5	4	3	6
Estimated Annual Adult Vaccines Provided	3265 (563–5811)	1160 (257–3449)	640 (231–2270)	561 (257–1112)	1395 (640–1640)	2859 (231–5811)
Annual Vaccine Dose Income[a] ($)[b]	47,271 (−4105–113,485)	9637 (−24,751–64,545)	−5507 (−30,248–5390)	−3060 (−24,751–−837)	−5507 (−18,832–4105)	44,276 (−30,248–113,485)
Annual Vaccine Administration Income[c] ($)[b]	44,430 (5356–136,142)	18,629 (−7908–76,489)	3723 (−43,203–35,313)	4540 (−7908–7908)	8457 (−33,275–35,313)	52,919 (−43,203–136,142)
Annual Total Vaccination Income[d] ($)[b]	90,343 (3968–249,628)	28,267 (−32,569–141,034)	2886 (−73,451–23,820)	3031 (−32,569–3968)	4352 (−38,782–16,481)	97,196 (−73,451–249,628)
Income Per Vaccine ($)[b]	21.55 (2.65–42.96)	21.88 (−127.25–44.21)	5.15 (−317.97–11.81)	4.00 (−127.25–7.05)	2.65 (−60.60–11.81)	38.48 (−317.97–44.21)

Notes:
Abbreviations: FM = Family Medicine; IM = Internal Medicine; OB-GYN = Obstetrics and Gynecology.
[a] Total annual vaccine dose income is defined as the difference between total annual payments received for vaccine doses and the total costs associated with vaccine doses (i.e., vaccine product and staff time spent on ordering, inventory management, and storage). Negative values represent losses.
[b] Income is reported in 2017 U.S. dollars.
[c] Total annual vaccine administration Income is defined as the difference between total annual payments received for vaccine administration and the total costs associated with vaccine management (i.e., staff time spent reviewing charts for upcoming patients, interfacing with the state immunization information system [IIS], administering the vaccine, and processing billing). Negative values represent losses.
[d] Annual total vaccination revenue is the sum of annual vaccine dose income and annual vaccine administration income . Negative values represent losses. Hypothetical Example Calculation: i. 600 vaccines administered per year. ii. Cost per vaccine of ordering, inventory management, storage, = $10. iii. Average vaccination purchase price = $60. iv. Average dose payment per vaccine = $75. v. Cost per vaccine of steps 3, 4, and 5 = $21. vi. Average administration payment per vaccine = $25. vii. Annual vaccine administration income = ($25 − $21)*600 = $2400 per year. viii. Annual vaccine dose income = ($75 – ($60 + $10))*600 = $3000 per year. ix. Annual total vaccination income = $2400 + $3000 = $5400 per year.

of 21 vaccines paid for at participating practices). Results show that practices reported receiving Medicare payments for 5 vaccines. Appendix Table A1 presents the range of prices paid for each vaccine dose, and Appendix Table A2 presents the range of payments received for each vaccine dose.

Table 5 presents estimates of average annual vaccinations given as well as median annual income and income per vaccination, stratified by practice type and wage tercile. By practice type, the median annual income for adult vaccinations was $90,343 for FM practices (range: $3968–$249,628), $28,267 for IM practices (range: −$32,659–$141,034) and $2886 for OB-GYN practices (range: −$73,451–$23,820). By wage tercile, the median annual income was $97,196 for practices in high cost areas (range: $−73,451–$249,628), $4,325 for practices in middle cost areas (range: −$38,782–$16,481) and $3031 for practices in low cost areas (range: −$32,569–$3968). Median income per vaccination was similar for FM and IM practices ($21.55 and $21.88, respectively) and lower for OB-GYN practices ($5.15). Vaccination services produced a positive income for 4 out of 4 FM practices, 3 out of 4 IM practices, and 3 out of 5 OB-GYN practices.

4. Discussion

Results from this study provide insight into vaccination-related income. Estimates in this study generally show vaccination can be profitable for FM, IM, and OB-GYN practices. Results showed substantial variation in both total annual income and income per vaccination both across and within practice types. Variation in income per vaccination seemed to be related to observed differences in cost and revenue per vaccination, whereas the variation in total annual income seemed to also be related to differences in the number of vaccinations given. A previous study has found that costs of vaccinations were lower in practices that administered more vaccines, due to economies of scale, and that spent less time with patients who, after consultation, chose not to receive a vaccination [15]. These cost drivers also have an effect on income, and suggest that practices may be able to increase income by better implementing processes such as standing orders and provider reminders to ensure that all vaccinations are given to patients according to the recommended schedule approved by ACIP.

Differences in revenues appear to be affected by several factors. In particular, payer mix, which is the percent of patients that carry each payer, had a substantial effect on the revenue of a practice due to the differences in payments among private payers, Medicare, and Medicaid. Payments for vaccine administration were comparable between Medicare and private payers, but were substantially lower from Medicaid. A similar pattern was observed in dose payments. Medicare payments for vaccine administration varied more by practice type than might be expected, which could be related to the geography of our sample since location is a primary factor for variations in Medicare and Medicaid payments. Differences in payments by payer may make it difficult for some practices to sustainably offer vaccination services, depending on the payer mix at a given practice. Payer mix across practices and payment variation across geographies are important considerations for policymakers seeking to reduce barriers to vaccination supply and increase adult vaccination rates. Practices reported receiving Medicare payments for 5 vaccines (covered by either Part B or Part D) despite vaccine recommendations for the Medicare population including more vaccines. Because Medicare coverage includes vaccines covered under Part B (medical insurance) and Part D (prescription drug benefit), Part D vaccines are only minimally administered at FM, IM, and OB-GYN practices as the billing for Part D covered vaccines is more easily done by pharmacies. This distinction between the types of Medicare coverage is important for practices to consider based on their patient population.

Another factor affecting revenue is the mix of vaccines given at a particular practice (i.e. the percentage of doses of each vaccine administered by the practice) due to differences between dose price and payment across vaccines. Differences between dose price and payment may make it difficult for practices to offer all vac-

cines. This is an important consideration for policymakers seeking to improve adult vaccination rates of any vaccines that may fall into this category. It is important for practices seeking to ensure the financial viability of their vaccination program to better understand cost and revenue drivers of each vaccine offered in their practice. Many practices, particularly IM and OB-GYN practices, may not stock all recommended vaccines because they are given infrequently. However, results demonstrate that these vaccines may still be profitable and by stocking them, practice may be able to increase economies of scale, reducing costs.

This study is subject to several limitations. First, family practices did not separate vaccines used for adults from those used for children, so we made assumptions about the distribution of vaccines that were given to both children and adults. Second, annual payments received for vaccines depend on the mix of payer types and we could not ascertain the precise mix of payer types for vaccine doses. While it is possible these issues may have resulted in an under or over-estimate of total annual income, the direction and extent of any bias is unknown. In addition, all prices were self-reported and may have included manufacturer or group purchasing discounts, particularly given that many of the study practices were part of larger health systems [16]. Second, we may have omitted certain management costs absorbed by the health system for the 6 practices that reported being part of a larger health system. Costs that would otherwise be incurred by the practice such as time spent on ordering or billing were underreported or not reported by the individual practices if they were incurred at the health system level; this would underestimate the costs of vaccination in these practices since we only observe costs to the practice and overestimate income. We did not distinguish between Medicare Part B and Part D, which may affect results if payments are different between the two. We conducted sensitivity analyses to test these assumptions, and they did not impact conclusions (Appendix Table A3). We observed and surveyed only 13 practices and our sample was not be representative of all practices providing adult vaccination. For example, many of the practices in our sample had 0% of their patients covered by Medicare or Medicaid while in the total population 17% are covered by Medicare and 19% are covered by Medicaid [17]. While not generalizable to the broader population of practices, these results indicate that the practices that provide healthcare to adults in our sample can generate profit from the provision of adult vaccines.

5. Conclusions

Practices that provide healthcare to adults have expressed concerns over the financial aspects of vaccination for adults such as inadequate or delayed reimbursement [9,10,18]. Income associated with vaccination can be difficult to quantify, because costs incurred for staff time specific to vaccination-related activities are difficult to assess and vaccine and payer mix must be carefully examined. This study collected the detailed cost and revenue data necessary to estimate the income associated with vaccination and determined that at the median all practice types receive at least a small positive net-revenue. Some financial concerns of providers appear to be validated by our study, such as reimbursement for specific vaccines being insufficient to cover prices paid for the vaccine. However, our overall finding remains that adult vaccination appears to be a financially viable healthcare service that can be provided by adult-focused physician practices.

Funding source

This report was prepared by RTI International, under contract HHSP233201500391 to the National Vaccine Program Office. The findings and conclusions of this article are those of the authors and do not necessarily represent the official position of National Vaccine Program Office or the Centers for Disease Control and Prevention.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.08.056.

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