Variation in Clinician Recommendations for Multiple Injections During Adoption of Inactivated Polio Vaccine

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ABSTRACT. *Objectives.* **To describe variation in clinician recommendations for multiple injections during the adoption of inactivated poliovirus vaccine (IPV) in 2 large health maintenance organizations (HMOs), and to test the hypothesis that variation in recommendations would be associated with variation in immunization coverage rates.**

Design. **Cross-sectional study based on a survey of clinician practices 1 year after IPV was recommended and computerized immunization data from these clinicians' patients.**

Study Settings. **Two large West Coast HMOs: Kaiser Permanente in Northern California and Group Health Cooperative of Puget Sound.**

Outcome Measures. **Immunization status of 8-month-olds and 24-month-olds cared for by the clinicians during the study.**

Results. **More clinicians at Group Health (82%), where a central guideline was issued, had adopted the IPV/oral poliovirus vaccine (OPV) sequential schedule than at Kaiser (65%), where no central guideline was issued. Clinicians at both HMOs said that if multiple injections fell due at a visit and they elected to defer some vaccines, they would be most likely to defer the hepatitis B vaccine (HBV) for infants (40%). At Kaiser, IPV users were more likely than OPV users to recommend the first HBV at birth (64% vs 28%) or if they did not, to defer the third HBV to 8 months or later (62% vs 39%).**

In multivariate analyses, patients whose clinicians used IPV were as likely to be fully immunized at 8 months old as those whose clinicians used all OPV. At Kaiser, where there was variability in the maximum number of injections clinicians recommended at infant visits, providers who routinely recommended 3 or 4 injections at a visit had similar immunization coverage rates as those who recommended 1 or 2. At both HMOs, clinicians who strongly recommended all possible injections at a visit had higher immunization coverage rates at 8 months than those who offered parents the choice of deferring some vaccines to a subsequent visit (at Kaiser, odds ratio [OR]: 1.2; 95% confidence interval [CI]: 1.0–1.5; at Group Health, OR: 1.8; 95% CI: 1.1–2.8).

Conclusions. **Neither IPV adoption nor the use of multiple injections at infant visits were associated with reductions in immunization coverage. However, at the HMO without centralized immunization guidelines, IPV adoption was associated with changes in the timing of the first and third HBV. Clinical policymakers should continue to monitor practice variation as future vaccines are added to the infant immunization schedule.** *Pediatrics* **2001;107(4). URL: http://www.pediatrics.org/cgi/content/full/107/4/e49;** ***immunizations, vaccines, provider practices, practice variation, inactivated polio vaccine.***

ABBREVIATIONS. IPV, inactivated polio vaccine; DTaP, diphtheria-tetanus-acellular pertussis vaccine; HMO, health maintenance organization; OPV, oral poliovirus vaccine; KP, Kaiser Permanente; GHC, Group Health Cooperative; Hib, *Haemophilus influenzae* type b vaccine; HBV, hepatitis B vaccine; MMR, measles-mumps-rubella; H-DTP, *Haemophilus influenzae* type b diphtheria-tetanus-acellular pertussis vaccine; OR, odds ratio; CI, confidence interval.

In the past decade, the number of injections recommended between birth and 18 months old has increased from 6 to a minimum of 11 and a maximum of 16.[1–3] Recent recommendations to use inactivated poliovirus (IPV)[4] and acellular diphtheria-pertussis-tetanus (DTaP)[5] vaccines have increased the immunization scheduling options open to clinicians and parents, as well as the required number of injections. Pneumococcal conjugate vaccination for infants, which the Advisory Committee on Immunization Practices has recommended, will add 4 more injections to this schedule.

When a child is due for multiple injections, parents and clinicians can elect to give them all simultaneously or to defer some vaccines until another visit.[6–9] Retrospective studies have suggested that missed opportunities attributable to deferred injections reduce immunization rates.[10–13] To date, there is little evidence that describes what clinicians recommend to parents when multiple injections are due or evaluates whether variation in such recommendations results in varying immunization coverage rates.

This study's aims were to: 1) describe the immunization practices of clinicians in 2 large health maintenance organizations (HMOs) after IPV and DTaP

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were recommended nationally; and 2) test the hypothesis that clinicians who recommend all vaccines simultaneously will have higher immunization coverage rates than those who offer parents the option of deferring some vaccines to later visits.

METHODS

Design

This cross-sectional study described the immunization practices of clinicians in 2 HMOs in spring 1998, ~1 year after the Advisory Committee on Immunization Practices recommended adoption of a sequential IPV/oral poliovirus vaccine (OPV) schedule. We evaluated associations between self-reported clinician practices and the immunization coverage rates of their patients identified using computerized databases.

Study Populations

We studied clinicians and children in 2 large nonprofit HMOs: Kaiser Permanente (KP), which has ~2.8 million members in Northern California, and Group Health Cooperative of Puget Sound (GHC), which has ~530 000 members in the Seattle area. Most members of these HMOs receive health insurance as an employment benefit. KP and GHC are both group-model HMOs in which a large provider group contracts exclusively with the health insurance plan to provide care to members for capitated (predetermined) fees.

At each health plan, we selected a survey population of ~300 clinicians, prioritizing those who were most active in providing immunizations to children. At KP, we first identified all staff clinicians (pediatricians and nurse practitioners) with patient panels that included children younger than 1 year old at any time during 1997. We included in the survey sample all clinicians whose panel included 100 or more children who met these criteria; this represented 76% of the initially identified clinicians. At GHC, we included in the survey sample all staff clinicians (pediatricians, family practitioners, nurse practitioners, and physicians' assistants) who conducted at least 1 well-child visit in 1997. In both HMOs, temporary clinicians who provided mainly urgent care, residents, and other clinicians known to have retired or to have left the health plans were ineligible for the survey.

For the patient samples, we identified all children in each HMO who: 1) turned 8 months old between January 1 and June 30, 1998; or 2) turned 24 months old between July 1 and December 31, 1998. These children were chosen because they were the ones whose immunization status was most likely to have been affected by clinician practices at the time of our survey in the spring of 1998. To study associations between clinician practices and immunization coverage, we needed to link each patient to his or her provider. We did this by first identifying the clinician at each vaccine-associated visit, defined as the outpatient clinic visit closest before, but not >7 days before, each vaccine date. Then, each patient was assigned to a clinician by the following hierarchical rules: 1) the clinician to whom the most vaccine-associated visits were made; 2) in case of ties, the clinician listed as the personal provider on the computerized database of the HMO; 3) in case of ties and no personal provider listed, the clinician to whom the most recent vaccine-associated visit was made; and 4) in case of no vaccine-associated visits, the one listed as the personal provider. If there were no vaccine-associated visits and no personal provider listed, the patient went unmatched.

HMO Immunization Guidelines

Within KP, each of the 17 hospital-based medical centers and 16 freestanding medical clinics could make a local decision about whether and when to adopt IPV and DTaP. Within each medical center, individual clinicians could make differing immunization recommendations based on their own preferences. The HMO had not developed regional or national guidelines for immunizations. All recommended immunizations were fully covered without copayment. KP did not make the combination *Haemophilus influenzae* type b-hepatitis B vaccine (Hib-HBV) available for use.

At GHC, a committee of clinicians published and regularly updated immunization recommendations for all clinicians in the HMO. At the time of this study, GHC recommended DTaP at 2, 4, 6, and 15 months and 4 to 6 years old, Hib-HBV at 2, 4, and 15 months old, IPV at 2 and 4 months old, OPV at 15 months and 4 to 6 years old, and measles-mumps-rubella (MMR) at 15 months old. All nationally recommended immunizations were fully covered without copayment except varicella vaccination. The guidelines recommended clinicians give parents a pamphlet about varicella vaccine at 15 months and gave clinicians the option of administering the vaccine.

Data Collection

In spring 1998, we mailed each clinician a self-administered survey that included 13 closed-ended questions about their immunization practices. The introduction to the survey said that we were interested in what each clinician actually recommended to parents, whether these recommendations differed from those of his or her department, and that responses would be used to help improve immunization practices. The survey asked about practices with regard to IPV/OPV and DTaP or *H influenzae* type b-diphtheria-tetanus-pertussis vaccine (H-DTP), as well as how strongly the clinician recommended having all shots due at 1 visit when 3, 4, and 5 shots were due. The survey also asked about provider demographics. Providers were given a small monetary incentive or a gift certificate, and 2 waves of mailings were sent. The study protocols were approved by the institutional review boards of each health plan.

At the time of this study, most parents of infants making their 2-month clinic visit at KP were offered enrollment in a study of pneumococcal conjugate vaccine, which would add an additional injection at 2, 4, 6, and 15 months of age. The KP clinician survey asked respondents to report what they would recommend about multiple shots for routine patients, ie, those who were not getting extra shots because of being in a vaccine study.

Definitions of Immunization Delay

We chose the 8-month and 24-month birthdates as the ages at which to categorize children as either up-to-date or delayed for immunizations. To be up-to-date at 8 months, children needed 3 DTP-type vaccines (either DTaP or H-DTP), appropriate Hib vaccines (at KP, 3 Hib and/or H-DTP; at GHC, 2 Hib-HBV or 3 Hib), 2 polio vaccines (either IPV or OPV), and appropriate HBV (defined at KP as 2 HBV and at GHC as 1 monovalent HBV after 3 weeks of age or 2 Hib-HBV vaccines). To be up-to-date at 24 months, children needed 4 DTP-type vaccines, appropriate Hib vaccines (4 Hib and/or H-DTP at KP; 3 Hib-HBV or 4 HIB at GHC), 3 polio vaccines, appropriate HBV (3 HBV at KP; 3 Hib-HBV or 2 HBV after 3 weeks at GHC), and 1 MMR.

Statistical Methods

Preliminary analyses used univariate and bivariate statistical methods, including cross-tabulations, to identify provider practice variables and other predictor variables that were candidates for inclusion as independent variables in subsequent analyses. In multivariate analyses, we used logistic regression techniques to evaluate associations between predictor variables and the outcomes (immunizations up-to-date vs delayed at 8 months or 24 months). Parameter estimation was conducted with generalized estimating equations,[14] (using the *SAS Macro, Version 2.03* for generalized estimating equations; SAS, Cary, NC) to account for the fact that patients of a single provider are clustered and are not statistically independent observations with regard to the dependent variable, their immunization status.

We constructed models separately for KP and GHC because immunization schedules differed between the 2 HMOs. For KP, we conducted separate models evaluating the effects on immunization status (the dependent variable) of different independent variables, including recommendations for 1) polio vaccination; 2) the maximum number of injections; and 3) options for deferring multiple injections. At KP, approximately one half of patients had enrolled in a trial of pneumococcal conjugate vaccine. For these patients, routine immunizations were ordered by the primary care clinicians but were administered by research nurses along with the experimental vaccine. To address the possibility that the research process might have influenced vaccine delivery, we conducted a secondary analysis that excluded patients in the pneumococcal vaccine study. For GHC, because there was very little variability in polio vaccination practices and the maximum num-

ber of injections, we only modeled the effects of options for deferring multiple injections.

RESULTS

Clinician Survey

Overall, 525 of the 585 eligible clinicians (90%) responded to the mailed survey (266/289 at KP and 259/296 at GHC). Of respondents at both HMOs, 63% had completed residency or professional training >10 years ago, while 25% had completed it 4 to 10 years ago, and 11% had completed it 3 or less years ago.

As Table 1 shows, clinicians reported greater variability in their polio vaccine recommendations at KP, where no guideline existed, than at GHC, where a central guideline recommended the IPV/OPV sequential schedule. The proportion of clinicians using the IPV/OPV sequential schedule was higher at GHC (82%) than at KP (65%). Among clinicians who recommended IPV at the 2-month visit, 66% of the combined sample said that they recommended it very strongly or somewhat strongly, whereas 32% said that they recommended it somewhat weakly or offered parents the choice between IPV and OPV.

Table 2 shows clinician recommendations when multiple injections were due. When 3 shots were due at a visit, most clinicians (76% overall) usually did not offer parents the option of deferring any shots to a follow-up visit. When 4 shots were due at a visit, 69% of KP clinicians usually did not offer parents the option of deferring any shots, whereas 63% of GHC clinicians said that they either offered the option of deferring shots or that this situation did not occur in their practice.

Clinicians reported that if they deferred any shots to a subsequent visit, they were most likely to defer hepatitis B vaccine for 0- to 11-month-olds (211 of the 525 respondents; 40%). At KP, IPV users were more likely to recommend the first HBV at birth (120/187 or 64%) than OPV users (13/46 or 28%; $P < .01$). However, among KP clinicians who were not recommending the first HBV at birth, IPV users (48/67 or 72%) were more likely than were OPV users (13/33 or 39%) to schedule the third HBV at 8 months or later ($P < .01$). Overall at KP, 124 of 266 clinicians (47%) reported recommending the third HBV at 8 months or later. GHC clinicians were not surveyed about their HBV practices because other analyses that we have conducted show minimal variability in these practices.[15]

Immunization Coverage

During the study, 11 582 infants at KP and 1411 infants at GHC turned 8 months old and were continuously enrolled from birth. Some patients were ineligible for study because they were not matched to any physician ($n = 369$ at KP and 191 at GHC) or because they were matched to a physician who was ineligible for the survey because of serving low numbers of infants ($n = 2996$ at KP and 2 at GHC). Among the 8217 eligible KP patients, 7655 (93%) were matched to a physician who had returned the survey. Among the 1218 eligible GHC patients, 1124 (92%) were matched to a physician who had returned the survey.

Of the infants in our final sample, 86% at KP and 77% at GHC were fully immunized by their 8-month birthdate. The DTP, Hib, and hepatitis B vaccines were the most frequently missed vaccines at KP; 7% lacked DTP and Hib only, 2% lacked hepatitis B only, and 1% lacked both. At GHC, the most frequent patterns among children underimmunized at 8 months old were DTP only (7%), DTP and Hib (4%), and hepatitis B only (2%).

Table 3 shows associations between clinicians' immunization recommendations and infants' immunization status at 8 months old. At KP, clinicians who used IPV or who recommended 3 or 4 injections at infant visits did not have different immunization rates compared with those who used OPV or who recommended 1 or 2 injections at infant visits. At both HMOs, infants were more likely to be fully immunized at 8 months old if their clinician reported strongly recommending all possible shots simultaneously, compared with always offering the parent the option of deferring 1 or more shots to a follow-up

TABLE 1. Poliovirus Immunization Recommendations of Clinicians Providing Well-Care Visits to Infants, Northern California KP and GHC of Puget Sound, 1998

Variable	HMO		
	KP *n* (%)	GHC *n* (%)	Combined *n* (%)
All respondents	266 (100)	259 (100)	525 (100)
Usual recommendation for poliovirus vaccination			
IPV/OPV sequential schedule	174 (65)	212 (82)	386 (74)
All-OPV schedule	46 (17)	24 (9)	70 (13)
All-IPV schedule	15 (6)	16 (6)	31 (6)
Equally recommend all above	31 (12)	6 (2)	37 (7)
How strongly clinicians recommended IPV at the 2-mo visit*†			
Very or somewhat strongly	137 (62)	162 (69)	299 (66)
Somewhat weakly or offered parents the choice between IPV and OPV	82 (37)	65 (28)	147 (32)
How often clinicians reported discussing that OPV was an alternative to IPV*†			
Never or usually not	36 (16)	111 (47)	147 (32)
About half the time	14 (6)	14 (6)	28 (6)
Usually	57 (26)	72 (31)	129 (28)
Always	111 (51)	31 (13)	142 (31)

* Eligible respondents included only those clinicians who recommended IPV for any patients at the 2-month visit.
† Percentages may not sum to 100 because the "no response" category is not shown.

TABLE 2. Recommendations Regarding Multiple Simultaneous Immunizations, Among Clinicians Providing Well-Care Visits to Infants, Northern California KP and GHC of Puget Sound, 1998

Variable	HMO		
	KP *n* (%)	GHC *n* (%)	Combined *n* (%)
Number of injections recommended at the 2-mo visit (or the maximum number at any visit between 2 and 6 mo)			
4	135 (51)	NA*	
3	70 (26)	NA*	
2 or 1	26 (10)	NA*	
Depends on parent choice	35 (13)	NA*	
Maximum number of injections recommended at any visit between 14 and 20 mo			
5 or 4	73 (27)	NA*	
3	62 (23)	NA*	
2, 1, or 0	120 (46)	NA*	
Depends on parent choice	11 (4)	NA*	
Usual practice when 3 shots due at a time†			
Usually do not offer the option to defer any	219 (82)	180 (70)	399 (76)
Usually or always offer option to defer 1 or more	46 (17)	75 (29)	121 (23)
Usual practice when 4 shots due at a time			
Usually do not offer the option to defer any	184 (69)	90 (35)	274 (52)
Usually or always offer option to defer 1 or more	69 (26)	109 (42)	178 (34)
Not applicable	12 (5)	55 (21)	67 (13)
For infants 0 to 11 mo old, if multiple shots were due and the clinician deferred some, which would they most likely defer?‡			
Hepatitis B	104 (39)	107 (41)	211 (40)
IPV	15 (6)	18 (7)	33 (6)
For children 12 to 24 mo old, if multiple shots were due and the clinician deferred some, which would they most likely defer?‡			
Hepatitis B	55 (21)	105 (41)	160 (31)
DTaP	39 (15)	24 (9)	63 (12)
Varicella	130 (49)	113 (44)	243 (46)

NA indicates not applicable.
* The survey at GHC did not ask this question because it was assumed, based on other analyses that we have conducted, that clinicians followed the guidelines of the HMO with minimal variability. At the 2-month visit, 3 injections were recommended; at the 15-month visit, 3 injections were recommended.
† One respondent at GHC replied "not applicable."
‡ This question specified "check all that apply." Because multiple responses were possible, percentages do not add to 100. For 0- to 11-month-olds, <5% of clinicians said they would defer the DTaP, Hib, or H-DTP. For 12- to 24-month-olds, <10% of clinicians said that they would defer the IPV, Hib, H-DTP, or MMR.

visit. This difference was statistically significant in the GHC model (odds ratio [OR]: 1.78; 95% confidence interval [CI]: 1.11–2.85) but not in the KP model (OR: 1.20; 95% CI: 0.99–1.45).

In both HMOs, Medicaid patients were less likely to be fully immunized at 8 months old compared with commercially insured patients (at KP, OR: 0.34; 95% CI: 0.12–0.94; at GHC, OR: 0.42; 95% CI: 0.30–0.61). Patients of nonwhite clinicians at KP had lower immunization rates (OR: 0.80; 95% CI: 0.68–0.95). Patient gender and years since the clinician completed residency training were not associated with immunization status in either HMO.

At KP, among the 8-month-olds in this study population, 3405 (44%) had participated in a randomized, controlled trial of pneumococcal conjugate vaccine. Because patients in this trial sometimes received their routine vaccinations from research nurses, we conducted a secondary analysis that excluded these patients. The general results of the analytic models for the remaining 4250 infants did not change. However, patients whose clinicians recommended an all-IPV schedule were significantly more likely to be fully immunized at 8 months old than those whose clinicians recommended all-OPV (OR: 1.61; 95% CI: 1.02–2.56).

We also analyzed the association of provider practices with the immunization status of children who turned 24 months old during the study. At 24 months of age, there were no differences in immunization coverage associated with how strongly clinicians said that they recommended all possible injections simultaneously. However, at KP, patients whose clinicians recommended a maximum of 4 injections at 1 of the visits between 12 and 18 months old had higher odds of being fully immunized at 24 months old than those whose clinicians recommended only 1 or 2 injections (OR: 1.41; 95% CI: 1.08–1.85). At KP, we conducted a secondary analysis restricted to 24-month-olds who had not participated in the pneumococcal conjugate vaccine trial ($n = 2866$ or 48% of the original 5973). Results were similar, but the association between clinicians' recommending a maximum of 4 injections at a visit between 12 and 18 months old and patients being fully immunized was not significant (OR: 1.10; 95% CI: 0.80–1.52).

DISCUSSION

Major Findings

This study found that neither IPV adoption nor the use of multiple injections at infant visits were associated with reductions in immunization coverage. At

TABLE 3. Associations Between Clinician Immunization Recommendations and Their Patients' Immunization Status at Eight Months, Northern California KP and GHC of Puget Sound, 1998

Predictor Variable	KP				GHC			
	Number of Infants	Number (%) Fully Immunized at 8 Months	OR*	95% CI*	Number of Infants	Number (%) Fully Immunized at 8 Months	OR*	95% CI*
All infants in study population	7655	6597 (86)	—	—	1124	860 (77)	—	—
Clinician recommendation for poliovirus vaccination†‡								
All OPV	1226	1049 (86)	1.00	—	8	5 (63)	—	—
IPV/OPV sequential	4979	4285 (86)	1.09	(0.87, 1.32)	1068	824 (77)	—	—
All IPV	583	508 (87)	1.24	(0.84, 1.84)	23	13 (57)	—	—
All 3 of above equally	867	755 (86)	1.16	(0.84, 1.60)	21	15 (71)	—	—
Maximum number of shots recommended at any visit between 2 and 6 mo§								
1, 2, or 3 shots	2756	2353 (85)	1.00	—	1124	860 (77)	—	—
4 shots	3938	3417 (87)	1.13	(0.94, 1.35)	—	—	—	—
Depends on parent choice	961	827 (86)	1.04	(0.80, 1.37)	—	—	—	—
							—	—
Clinician recommendation when 3 or 4 shots due at once‖								
Always or usually offer option of deferring	2077	1752 (84)	1.00	—	125	86 (69)	1.00	—
Strongly recommend all shots simultaneously	4740	4106 (87)	1.20	(0.99, 1.45)	991	771 (78)	1.78	(1.11, 2.85)
Years since completion of training¶								
0–10	3498	3024 (86)	—	—	386	306 (79)	—	—
11 or more	4157	3573 (86)	—	—	736	552 (75)	—	—
Clinician race/ethnicity†								
White	4534	3958 (87)	1.00	—	964	741 (77)	1.00	—
Nonwhite	3025	2560 (84)	0.80	(0.68, 0.95)	117	83 (71)	0.64	(0.39, 1.07)
Infant gender¶								
Male	3891	3351 (86)	—	—	554	419 (76)	—	—
Female	3764	3246 (86)	—	—	570	441 (77)	—	—
Infant Medicaid status†								
Never had Medicaid	7638	6586 (86)	1.00	—	948	752 (79)	1.00	—
Had Medicaid during 0–8 mo	17	11 (65)	0.34	(0.12, 0.94)	176	108 (61)	0.42	(0.30, 0.61)

* Adjusted OR and 95% CI are from generalized estimating equation analyses performed separately on KP and GHC data. The reference group for ORs is the predictor level with OR equal to 1. Models 1 to 3 were for KP: model 1 included polio recommendations, clinician race/ethnicity, and Medicaid; model 2 included the maximum number of shots recommended at any visit between 2 and 6 months, clinician race/ethnicity, and Medicaid; and model 3 included clinician recommendation when 3 or 4 shots due at once, clinician race/ethnicity, and Medicaid. Model 4 was for GHC and included clinician recommendation when 3 or 4 shots due at once, clinician race/ethnicity, and Medicaid.

† The ORs are from model 1.

‡ The GHC analysis excluded this variable since the great majority of GHC clinicians followed the IPV/OPV sequential schedule.

§ The ORs are from model 2. The GHC analysis excluded this variable because all clinicians were assumed to have followed guidelines that recommended 3 injections at the 2-month visit and 3 injections at the 15-month visit.

‖ The ORs are from models 3 and 4. In the KP analysis, this predictor was coded as the recommendation made for the maximum number of injections the provider reported giving at any visit between 2 and 6 months of age. In the GHC analysis, this predictor was coded as the recommendation made when 3 shots were due.

¶ This variable was not included in models and no OR is given because no association was found in preliminary analysis.

Kaiser, where no central guideline for IPV use was issued, IPV adoption was slower and was associated with deferral of the third hepatitis B vaccine to later infant visits. At both HMOs, clinicians who strongly recommended all possible injections simultaneously had higher coverage rates for 8-month-olds.

Comparisons With Other Studies

The current research is unique in that we linked the self-reported practices of clinicians with the immunization outcomes of their patients. Previous immunization studies have used either patient records[10–13] or provider surveys,[6–9,16–20] but we are aware of only 1 other study that has attempted to directly evaluate associations between these. In the previous study, Taylor et al[21] found that individual clinicians were the variable most strongly associated with immunization status in statistical models but could not pinpoint which clinician recommendations were important because the study included only 15 pediatricians. The current study, which included 525 clinicians and nearly 9000 eight-month-olds, had the statistical power and variability to identify specific clinician recommendations associated with immunization coverage.

Our findings differ from those of physician surveys in the mid-1990s in which providers expressed reluctance—when presented with hypothetical situations of 3 or 4 injections being due at a visit—to administer multiple injections.[7–9] A 1997 survey found that most providers would not defer injections when 3 were due at a visit.[19] Currently, 4 injections falling due at infant visits is routine rather than hypothetical in the larger HMO that we studied. In

our study, most providers said that they would recommend 4 injections at a given visit, and most of these said that they usually did not offer parents the option of deferring any injections to a follow-up visit.

Our finding that IPV adoption was not associated with delayed immunization agrees with our analysis of computerized immunization tracking data.[15] At KP, IPV users tended to give the first hepatitis B at birth, a practice associated with timely receipt of other vaccines in another study.[22] However, IPV introduction at KP seemed to cause clinicians who were not giving the first HBV at birth to schedule the third HBV later (at 8 months or later). Because the third HBV can be given any time between 6 and 18 months of age, follow-up studies will be needed to determine whether scheduling the third HBV after the 6-month visit will cause this vaccine to be missed. Our analyses to date have not found decreased immunization coverage of 24-month-olds overall.

This work has broad implications for children's health care delivery because it identifies an area of practice variation that potentially affects all US infants. The possibility that reducing practice variation can improve outcomes has been studied in adult conditions with varying results.[23–25] Few studies in pediatrics have evaluated whether practice variation results in differences in outcomes.[26–28] Some flexibility in vaccine scheduling seems warranted based on the variation in available combination vaccines and parent and clinician preferences. However, continued monitoring is warranted to ensure that such variation does not lead to reduced immunization coverage rates.

Limitations

This study was conducted in 2 closed-panel HMOs, 1 a staff-model and 1 a group-model, which have relatively cohesive provider groups. Other settings with more loosely organized provider networks and variable forms of reimbursement for vaccines are likely to have even greater variation in vaccine scheduling. Such variation will probably increase in the near future, when pneumococcal conjugate vaccination is introduced.

Our findings are most generalizable to insured populations with access to primary care providers. Relative to other factors, clinician recommendations might be a less potent influence on immunization status for children who lack either financial coverage for immunizations or primary care providers. At the larger HMO in this study, we excluded from the survey the 24% of clinicians who were least active in providing care to infants, who were often specialists. The findings, thus, may underrepresent the practices of physicians who see small numbers of infants for immunizations. However, there is little reason to believe that the associations that we observed between clinician recommendations and immunization coverage would not generalize to this group.

The associations observed in this study cannot be interpreted as causal relationships. For example, the fact that providers who strongly recommended all injections simultaneously had higher immunization coverage rates among 8-month-olds could have been caused by factors that this study did not evaluate, such as more adherent patient populations or local clinical interventions. We did not observe a similar association between strongly recommending all injections simultaneously and immunization coverage rates among 24-month-olds. However, clinicians who recommended a maximum of 4 or 5 injections at a visit between 12 and 18 months old had higher coverage rates for 24-month-olds than did those who recommended fewer injections simultaneously.

CONCLUSION

Neither IPV adoption nor the use of multiple injections at infant visits were associated with reductions in immunization coverage. However, at the HMO without centralized immunization guidelines, IPV adoption was associated with changes in the timing of the first and third HBV. Clinical policymakers should continue to monitor the effects of multiple injections and practice variation as future vaccines are added to the infant immunization schedule.

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