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# Missed Opportunities for Adolescent Vaccination, 2006–2011

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A B S T R A C T

**Objective:** To describe missed opportunities for meningococcal (MCV); tetanus, diphtheria, acellular pertussis (Tdap); and human papillomavirus (HPV) vaccination among adolescents.
**Methods:** Retrospective electronic health record data review of adolescents aged 11–18 years at the time of their visit to a university-based pediatric practice in Seattle from 2006 to 2011. The primary outcome was missed vaccination opportunities, defined as the proportion of visits where a patient eligible for MCV, Tdap, and/or HPV remained unvaccinated. HPV vaccine analysis was limited to females. Bivariate and multivariate logistic regression assessed variables associated with missed vaccination opportunities.
**Results:** During the study period, 1,628 adolescents made 9,180 visits. The percentage of visits that were missed opportunities was 82% for MCV, 85% for Tdap, and 82% for the first HPV dose (HPV1), 63% for the second, and 71% for the third. Adolescents with at least one preventive care visit were significantly less likely to have missed opportunities for MCV, Tdap, or HPV1. Nonpreventive visits were associated with more missed opportunities for MCV (OR = 19.2, 95% CI 15.3–24.0), Tdap (OR = 25.8, 95% CI 19.3–34.6), and HPV1 (OR = 12.1, 95% CI 9.0–16.1) than preventive visits. Adolescent females were more likely to have a missed opportunity for HPV1 than Tdap ($p < .001$) or MCV ($p = .03$).
**Conclusions:** Missed opportunities for adolescent vaccination against MCV, Tdap and HPV are common. Adolescents who utilize preventive care are less likely to have missed vaccination opportunities. Further research is needed to explore why missed vaccination opportunities occur and to develop evidence-based strategies to reduce missed opportunities and improve adolescent vaccination coverage.



**IMPLICATIONS AND CONTRIBUTION**

Missed opportunities for adolescent vaccination against meningococcal; tetanus, diphtheria, acellular pertussis; and human papillomavirus are common. Adolescents who utilize preventive care are less likely to have missed vaccination opportunities. Reducing missed vaccination opportunities would improve adolescent vaccination coverage.

Although vaccines have been at the core of preventive care for infants and young children, they have not been a major component of adolescent preventive care, primarily because there were few vaccines recommended for adolescents. Recently, three vaccines have been routinely recommended for adolescents. The meningococcal conjugate vaccine (MCV) was routinely recommended in 2005 [1]. The tetanus, diphtheria, acellular pertussis vaccine (Tdap) replaced the adolescent tetanus, diphtheria booster (Td) in 2006 [2]. Lastly, the human papillomavirus (HPV) vaccine was routinely recommended for adolescent females in 2006 [3]. These vaccines have drawn increased focus to the approach for vaccinating adolescents [4]. These adolescent vaccines provide an opportunity to protect against acute illnesses as well as engage adolescents with the healthcare system to

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deliver other important preventive services [5]. Rates of adolescent vaccination in the United States, however, remain low [6], especially when compared with the high level of early childhood vaccination coverage achieved [7].

Missed vaccination opportunities have been shown to contribute to lower vaccination rates among children and adults [8–11]. A missed vaccination opportunity occurs when a vaccine-eligible patient is seen for care but remains unvaccinated. Missed opportunities may be particularly critical among adolescents because of their lack of regular visits to medical providers [12–17]. However, less is known regarding missed vaccination opportunities among adolescents, particularly for the more recently recommended MCV, Tdap, and HPV vaccines. Identifying patterns of missed opportunities for vaccination could inform the development of strategies to increase vaccination rates among adolescents.

The primary aim of this study was to describe missed opportunities for MCV, Tdap, and HPV vaccination among adolescents 11 to 18 years old seen at a primary care pediatric clinic from 2006 to 2011. Secondary outcomes included identifying variables associated with missed opportunities for vaccination. We hypothesized that adolescents have significant missed vaccination opportunities and that there are more missed opportunities for HPV than for Tdap or MCV vaccination given the overall lower HPV vaccine uptake and reported parental and provider barriers to HPV vaccination [6,18,19].

## Methods

### *Study population*

The study population included adolescents seen at a university-based pediatric teaching clinic in Seattle, Washington from November 6, 2006 through June 30, 2011. This clinic provides comprehensive primary care for babies, children, adolescents, and young adults through age 21 years. Providers include faculty pediatricians, pediatric residents, and nurse practitioners; approximately 15,000 pediatric visits are made to the clinic per year. During the study period, no vaccine reminder or recall system was used for adolescents. The study start date of November 6, 2006 was selected because it was the date of the first HPV vaccine administered at the clinic, shortly after Washington State Vaccine for Children program included the vaccine in their program [20]. Study inclusion criteria were clinic visits made for any reason during the study period by adolescents aged 11 to 18 years at the time of the visit. These patients and visits were identified by patient date of birth and age at visit in the electronic health record (EHR).

### *Study design*

Information from the clinic's EHR system was used to perform a retrospective data review. All immunization inventory, orders, and patient records are maintained in the clinic's EHR. Extracted patient variables included gender, age at each visit, and insurance coverage. Visit information included visit date, provider type (faculty, resident, or nurse practitioner), and visit type (preventive care visit, vaccine-only visit, or other nonpreventive visit). A subset of the preventive visits was defined as 11- to-12-year-old preventive visits, the age range recommended by the Advisory Committee on Immunization Practice (ACIP) for routine vaccination against MCV, Tdap, and HPV and for a preventive health care visit in the adolescent vaccination platform [12,21–23].

Vaccination variables included date of vaccination and age at vaccination for MCV, Tdap, and HPV first dose (HPV1), second dose (HPV2), and third dose (HPV3). Each vaccine occurrence was identified in the EHR per vaccine administration. The EHR vaccination documentation was considered complete because (1) vaccine entry into EHR was used for billing purposes; and (2) verification through reconciliation of vaccine doses obtained to those administered or wasted was completed using lot numbers. We further inspected this electronic immunization data for quality by conducting checks for outliers, spacing of vaccines, and receipt order of vaccines. HPV vaccination was only examined in females because the routine male HPV vaccination recommendation was made by the Advisory Committee on Immunization Practice (ACIP) in October 2011 [24]. We excluded the 10 patient visits that resulted in a second dose of MCV from the MCV analysis because these second doses reflected the updated ACIP recommendation made in October 2010 were only applicable to a small portion of the study period; other vaccines received at these visits were still eligible for analysis [25]. We chose to not assess influenza vaccination status because of the need for yearly revaccination.

The primary study outcome was missed opportunities for vaccination for MCV, Tdap, and HPV1. A missed opportunity for vaccination was defined as a visit when a patient was age-eligible for a vaccine (meaning that the patient was due for the vaccine per ACIP recommendations and had not received it previously) and remained unvaccinated at the visit. Because we did not review the specific content of visits, we were unable to identify whether a specific contraindication to vaccination existed, and instead considered all visits of unimmunized adolescents as vaccine-eligible visits because the absolute and relative contraindications to vaccinations are uncommon [8,26]. Additionally, we were unable to assess whether missed vaccination opportunities resulted from parent/patient refusal or providers not administering eligible vaccines. Of note, there was a shortage of MCV in 2006 [27], and the ACIP recommendation for MCV in 2005 for persons aged 11–12 years, those entering high school, and college freshman living in dormitories was expanded to routine vaccination for teens 11–18 years old in June 2007 [1,28]. We therefore conducted two analyses using MCV eligibility defined as beginning on November 6, 2006 and as beginning in June 2007. Visits occurring more than 4 weeks after HPV1 were considered eligible visits for HPV2; visits at least 12 weeks after HPV2 were considered eligible for HPV3 per the ACIP guidelines [3]. These dosing intervals were compared with eligibility for HPV2 and HPV3 at 2 months and 6 months following first dose, respectively.

Secondary outcomes included identifying patient and visit characteristics associated with missed opportunities for vaccination. We also described vaccination coverage for each vaccine and rates of up-to-date (UTD) for all adolescent vaccines for the study participants during the study period. UTD for adolescent females included vaccination with a single dose of MCV, single dose of Tdap, and 3 doses of HPV vaccine during the study time period. UTD for adolescent males was defined as receipt of a single dose of MCV and a single dose of Tdap.

### *Data analysis*

We calculated the vaccination coverage for the study period, with HPV vaccine analysis limited to females only. For the

analyses of missed vaccination opportunities, the unit of analysis was the visit. Missed opportunities for a specific vaccine were calculated as the total number of visits at which a patient was eligible for the vaccine and it was not given divided by the total number of visits at which a patient was eligible for the vaccine (i.e., visits at which the vaccine was not given plus visits at which the vaccine was administered). We examined all combinations of missed vaccination opportunities for MCV, Tdap, and HPV vaccinations. Missed opportunities were examined by visit type in bivariate and fixed effect logistic regression analysis, which accounted for multiple visits by the same individual. Missed opportunities were also assessed by age group (11–12 years, 13–15 years, and 16–18 years). Odds ratios (ORs) and 95% confidence intervals (CIs) were computed. *P* values <.05 were considered statistically significant. Missed opportunities between MCV, Tdap, and HPV1 were compared by analyzing the missed vaccination opportunities at each patient's first 11- to-12-year-old preventive visit using the McNemar test, a test used in the analysis of pairs of matched, binary outcome data.

Multivariate logistic regression was performed to assess variables associated with missed opportunities for vaccination. The following predictors were included in the multivariate model: gender, insurance, and number of preventive visits (1 or ≥2 visits) during study time period. All analyses were performed with Stata 11.0 (Stata, College Station, TX). The Institutional Review Board of Seattle Children's Hospital approved this study protocol.

## Results

### *Study population*

There were 1,628 adolescents who met study inclusion criteria. Females comprised 54% of the study population (Table 1). Approximately 40% of the participants were privately insured, while 51% were publically insured. In total, these adolescents made 9,180 visits. The average number of visits per patient was 5.6. Of these visits, 28% were for preventive care, 13% for vaccine-only, and 59% for nonpreventive care. Of the preventive visits, 28% occurred while the adolescent was 11 to 12 years old.

### *Vaccination*

Vaccination coverage across the study period was 57% for MCV and 54% for Tdap (Table 1). HPV vaccine coverage for females decreased with each sequential dose: 58% for HPV1, 45% for HPV2, and 35% for HPV3. The percentage of adolescents UTD for all adolescent vaccines was 33%. The vaccines most commonly administered concurrently were MCV and Tdap (437 visits). The majority of MCV (79%), Tdap (71%), and HPV1 (72%) were administered at preventive care visits, while HPV2 (59%) and HPV3 (53%) were predominantly given at vaccine-only visits.

### *Missed opportunities for vaccination*

The overall proportion of visits that were missed opportunities for vaccination was 82% for MCV, 85% for Tdap, and 82% for female HPV1 (Table 1). At visits where patients were eligible for both MCV and Tdap, 9.1% of females and 12.3% of males received both. The missed opportunities for vaccination varied by age at visit with decreased missed opportunities for HPV with increasing age: 56.8% for 11–12 years, 37.3% for 13–15 years, and 35.3% for 16–18 years. Nonpreventive visits were associated with the greatest percentage of missed opportunities for vaccination for MCV (96%), Tdap (97%), and HPV1 (94%) (Table 2). In logistic regression modeling, nonpreventive visits were associated with more missed opportunities for MCV (OR = 19.2, 95% CI 15.3–24.0), Tdap (OR = 25.8, 95% CI 19.3–34.6), and HPV1 (OR = 12.1, 95% CI 9.04–16.1) than preventive visits (Table 2). Using June 2007 as the start date for MCV eligibility yielded similar results for MCV missed opportunities.

For the HPV vaccine series, females had significantly fewer missed opportunities for HPV2 and HPV3 at vaccine-only visits compared with preventive visits, indicating that the second and third doses are more likely given at vaccine-only visits (Table 2). Analysis of missed opportunities for HPV2 and HPV3 using eligibility criteria of visits 2 months and 6 months after the first dose, respectively, yielded similar results.

Among male and female adolescents, missed vaccination opportunities for MCV were more likely than Tdap ($p < .001$) at their first 11- to-12-year-old preventive visit. Females were more likely to have a missed vaccination opportunity for HPV1 than

**Table 1**
Characteristics of study patient population (N = 1628) and visits (N = 9180)

| | |
|---|---|
| Patient characteristics | |
| Age at visit, mean (median) | 14.7 (14.6) |
| Gender, n (%) | |
| Female | 875 (53.8) |
| Insurance, n (%) | |
| Private | 655 (40.2) |
| Public | 831 (51) |
| Other | 52 (3.2) |
| Unknown | 90 (5.5) |
| Primary care provider type | |
| Faculty | 812 (49.9) |
| Resident | 597 (36.7) |
| Nurse practitioner | 208 (12.8) |
| Visit characteristics | |
| Average number of visits per patient | 5.6 |
| Visit type, n (%) | |
| Preventive care visit | 2,537 (27.8) |
| 11–12-year-old preventive visit | 710 (7.7) |
| Vaccine-only visit | 1,212 (12.9) |
| Nonpreventive visit | 5,431 (59.3) |
| Vaccination characteristics | |
| Vaccination coverage during study, n (%) | |
| MCV | 932 (57.3) |
| Tdap | 878 (53.9) |
| HPV1[a] | 508 (58.1) |
| HPV2[a] | 396 (45.3) |
| HPV3[a] | 302 (34.5) |
| UTD on all adolescent vaccines, n (%)[b] | 529 (32.5) |
| Missed opportunities for vaccination, n (%)[c] | |
| MCV | 4,228 (82.1) |
| Tdap | 4,618 (84.6) |
| HPV1[a] | 2,256 (81.9) |
| HPV2[a] | 659 (63.1) |
| HPV3[a] | 709 (71.3) |

HPV1 = human papillomavirus first dose; HPV2 = human papillomavirus second dose; HPV3 = human papillomavirus third dose; MCV = meningococcal conjugate vaccine; Tdap = tetanus, diphtheria, acellular pertussis vaccine; UTD = up-to-date.

[a] Analysis for HPV limited to females only.

[b] Up-to-date on all adolescent vaccines defined for females receipt of 1 dose of MCV, 1 dose of Tdap and 3 doses of HPV with ≥4 weeks between HPV1/HPV2 and ≥12 weeks between HPV2/HPV3; and for males as receipt of single doses of MCV4 and Tdap.

[c] Denominator for missed opportunities for MCV and Tdap is 9,180 visits. Denominator for missed opportunities for HPV is 5,475.

**Table 2**
Missed opportunities for adolescent vaccination of MCV, Tdap, and HPV, by visit type

| Vaccine | Type of visit (n) | Eligible at time of visit n (%) | Received at visit n (% of eligible) | Missed opportunity n (% of eligible) | Logistic model[a] of missed opportunities OR (95% CI) |
|---|---|---|---|---|---|
| MCV | Preventive care (2,537) | 1,678 (66.1) | 724 (43.2) | 954 (56.8) | 1 |
| | Vaccine-only (1,212) | 527 (43.5) | 74 (14) | 453 (86) | 4.82* (3.62–6.40) |
| | Nonpreventive (5,431) | 2,944 (54.2) | 123 (4.2) | 2,821 (95.8) | 19.2* (15.3–24) |
| Tdap | Preventive care (2,537) | 1,675 (66) | 593 (35.4) | 1,082 (64.6) | 1 |
| | Vaccine-only (1,212) | 680 (56.1) | 158 (23.2) | 522 (76.8) | 1.56* (1.20–2.02) |
| | Nonpreventive (5431) | 3,103 (57.1) | 89 (2.9) | 3,014 (97.1) | 25.8* (19.3–34.6) |
| HPV1[b] | Preventive care (1,394) | 905 (64.9) | 357 (39.5) | 548 (60.6) | 1 |
| | Vaccine-only (857) | 263 (30.7) | 47 (17.9) | 216 (82.1) | 3.10* (2.12–4.54) |
| | Nonpreventive (3,224) | 1586 (49.2) | 94 (5.9) | 1,492 (94.1) | 12.1* (9.04–16.1) |
| HPV2[b] | Preventive care (1,394) | 219 (15.7) | 74 (33.8) | 145 (66.2) | 1 |
| | Vaccine-only (857) | 289 (33.7) | 229 (79.2) | 60 (20.8) | .05* (.03–.12) |
| | Nonpreventive (3,224) | 537 (16.7) | 83 (15.5) | 454 (84.5) | 5.70* (2.87–11.3) |
| HPV3[b] | Preventive care (1,394) | 233 (16.7) | 71 (30.5) | 162 (69.5) | 1 |
| | Vaccine-only (857) | 231 (27) | 150 (65.0) | 81 (35.1) | .17* (.06–.47) |
| | Nonpreventive (3,224) | 530 (16.4) | 64 (12.1) | 466 (87.9) | 37.9* (9.67–148.9) |

HPV1 = human papillomavirus first dose; HPV2 = human papillomavirus second dose; HPV3 = human papillomavirus third dose; MCV = meningococcal conjugate vaccine; Tdap = tetanus, diphtheria, acellular pertussis vaccine.
[a] Variables in logistic model: Missed opportunity for each vaccine, visit type.
[b] Analysis for HPV vaccine limited to females only.
* $p < .05$.

Tdap ($p < .001$) or MCV ($p = .03$) at their first 11- to-12-year-old preventive visit. Though fewer missed opportunities for MCV (OR = .75, 95% CI .60–.94) and Tdap (OR = .26, 95% CI .20–.35) occurred at 11- to-12-year-old preventive visits than preventive visits made at older ages, no statistically significant difference in missed opportunities for HPV1 (OR 1.41, 95% CI .98–2.02) was found at the 11- to-12-year-old preventive visits (Table 3).

*Predictors of missed opportunities for vaccination*

In multivariate regression models, adolescents who had at least one preventive care visit were significantly less likely to have missed opportunities for MCV (OR = .19 for 1 visit, .17 for ≥2 visits), Tdap (OR = .24 for 1 visit, .19 for ≥2 visits) or HPV1 (OR = .34 for 1 visit, .29 for ≥2 visits) than those who didn't have any preventive visits (Table 4). No significant differences in missed vaccination opportunities by gender or insurance type were found.

## Discussion

Our results support previous findings that missed opportunities for adolescent vaccination are common and expand on this research to include the more recently recommended adolescent vaccines [29]. Specifically, we found that nonpreventive visits were associated with the most missed opportunities for MCV, Tdap, and HPV1; whereas adolescents who utilized preventive care visits were less likely to have missed opportunities for MCV, Tdap, or HPV1. Adolescent females were more likely to have a missed opportunity for HPV1 than Tdap or MCV at the first adolescent 11-to-12-year-old preventive care visit. There were substantial missed opportunities for second and third HPV doses, with most doses of HPV2 and HPV3 administered at vaccine-only visits. Additionally, there was a lack of concurrent vaccine administration in eligible teenagers. The high incidence of missed opportunities for vaccination contributed to the suboptimal adolescent vaccine coverage in our study.

Though we found missed opportunities across all visit types, the high percentage of missed vaccinations at nonpreventive encounters presents an opportunity to markedly increase adolescent

**Table 3**
Missed opportunities for adolescent vaccination at the 11–12-year-old preventive care visit

| Vaccine | Eligible at time of visit n (%) | Received at visit n (% of eligible) | Missed opportunity n (% of eligible) | Logistic model of missed opportunities at 11–12-year-old preventive care visits[b] OR (95% CI) |
|---|---|---|---|---|
| MCV | 608 (85.6) | 292 (48) | 316 (52) | .75* (.60–.94) |
| Tdap | 521 (73.4) | 287 (55.1) | 234 (44.9) | .26* (.20–.35) |
| HPV1[a] | 350 (86.6) | 127 (36.3) | 223 (63.7) | 1.41 (.98–2.02) |

HPV1 = human papillomavirus first dose; MCV = meningococcal conjugate vaccine; Tdap = tetanus, diphtheria, acellular pertussis vaccine.
[a] Analysis for HPV vaccine limited to females only.
[b] Variables in logistic model: Missed opportunity for each vaccine, visit type. Comparison group is 13-to-18-year-old preventive care visits.
* $p < .05$.

**Table 4**
Multivariate analysis of variables associated with missed opportunities for adolescent vaccination

| | ≥1 Missed opportunity for MCV OR (95% CI) | ≥1 Missed opportunity for Tdap OR (95% CI) | ≥1 Missed opportunity for HPV1[a] OR (95% CI) |
|---|---|---|---|
| Gender | | | |
| Female | 1 | 1 | – |
| Male | .95 (.75–1.20) | .92 (.73–1.15) | – |
| Insurance | | | |
| Private | 1 | 1 | 1 |
| Public | .87 (.68–1.11) | .81 (.63–1.02) | .86 (.61–1.21) |
| Other | .82 (.40–1.69) | 1 (.48–2.10) | .51 (.23–1.08) |
| Unknown | 1.09 (.63–1.90) | .81 (.49–1.35) | .78 (.38–1.61) |
| Number of preventive care visits | | | |
| None | 1 | 1 | 1 |
| 1 | .19* (.12–.31) | .24* (.15–.37) | .34* (.20–.59) |
| ≥2 | .17* (.10–.27) | .19* (.12–.29) | .29* (.17–.49) |

MCV = meningococcal conjugate vaccine; Tdap = tetanus, diphtheria, acellular pertussis vaccine; HPV1 = human papillomavirus first dose.
* $p < .05$.
[a] Analysis for HPV vaccine limited to females only.

vaccination coverage. The association of nonpreventive visits with more missed opportunities was also found in a study of tetanus-diphtheria adolescent vaccination from 1997 to 2004 [29]. This pattern indicated that these visits were not being considered potential vaccination encounters. In a national survey of physicians, less than half reported checking vaccination status of adolescents at acute care visits [30]. Our data supported this gap in preventive care and highlights the need for providers and clinics to assess adolescents' vaccination status and consider vaccination at all clinic visits.

Reducing missed vaccination opportunities is especially important among adolescents because most teenagers are not seen regularly for preventive care or even sick visits [12–16]. Though the patients in our study made on average at least one visit per year, only 28% of adolescent visits were preventive, with approximately one third of these occurring at ages 11 to 12 years. Given adolescents' infrequent use of health care and the pattern of fewer missed opportunities at preventive visits, the over 50% of eligible preventive care visits in our study that resulted in missed vaccination opportunities was particularly concerning. The ACIP and several professional organizations recommend that adolescent vaccines be routinely administered at the 11-to-12-year-old visit as part of the adolescent vaccination platform, with evolving evidence that vaccination may provide incentive for teenagers to more regularly access preventive health care [5,12,22,23,31,32]. Our findings that adolescents who utilize preventive care, particularly for an early adolescent 11-to-12-year-old check-up, were less likely to have missed vaccination opportunities support the effort to promote an adolescent vaccination platform and regular preventive health care visits for adolescents.

Adolescent females were more likely to have a missed opportunity for HPV vaccine than MCV or Tdap at their 11-to-12-year-old preventive care visit. Additionally, we found decreasing rates of missed vaccination opportunities for HPV1 in older females. In a review of national adolescent immunization data from 2006 to 2009, the gap between actual and potential vaccine coverage decreased over time for Tdap, remained the same for MCV, and increased for HPV [33]. The national disparity in HPV vaccine coverage is likely due in part to limited provider recommendations for HPV vaccination, especially for younger teenagers [34]. This may be the case in our study as well, although no documentation of vaccine refusal or absence of provider counseling was analyzed. Common parental barriers to HPV vaccination are beliefs that the vaccine is not needed, denial of their daughter's current or future sexual activity, and an overall lack of vaccine knowledge [18,19]. Beyond the bundling of adolescent vaccinations in a platform, targeting HPV vaccination at age 11 to 12 years is especially important because it is most effective if given before the onset of sexual activity [3]. Of note, the greatest likelihood of HPV1 vaccination in our study was at a preventive visit when examining all ages.

Additionally, HPV vaccine is a three-dose series that has been challenging for girls to complete in our study and nationally [6,33]. In our clinic setting, most second and third HPV vaccine doses were administered at vaccine-only visits. Based on this finding, scheduling future vaccine-only visits for the second and third HPV doses at the time of the first HPV vaccination may increase HPV vaccine series completion. Finally, monitoring missed opportunities for male HPV vaccination since its routine recommendation in 2011 will be important, with the hope of decreasing missed opportunities with the reversal of gender-targeted HPV vaccination [24,35].

Another contributor to missed vaccination opportunities was the lack of concurrent adolescent vaccination [6,33]. The significant number of missed vaccination opportunities we found at vaccine-only visits, meaning that children were coming in specifically for a vaccine but not concurrently receiving other vaccines for which they were eligible, highlights the need for increased administration of all age-appropriate vaccine doses, as recommended by the ACIP [36]. As another example, only 9.1% of females and 12.3% of males received both MCV and Tdap at visits where they were eligible for both. Further research is needed to explore why providers fail to administer all indicated vaccines concurrently during adolescent health visits.

The findings in this report were subject to several limitations. Similar to most adolescent vaccine studies, we were limited by vaccination record scatter with adolescents receiving vaccines at different sites, such as schools and teen clinics. The vaccine registry for Washington State is not yet considered reliable for assessing adolescent immunization coverage, so some teens in our study may have had incomplete vaccination documentation [13,30]. However, the patients in the study population made an average of 5.6 visits during the 5-year study time period, indicating that many of these adolescents utilize this practice as their medical home. Additionally, this visit frequency is similar to that reported in other studies, indicating generalizability of the study results [37]. Additionally, yearly HPV vaccination rates for the clinic approximate U.S. and Washington State rates.

Our study was limited to an academic practice in a metropolitan area in Washington State, making the results less generalizable. However, as a strength, this study clinic does serve a diverse population representative of the racial-ethnic, socioeconomic, and insurance coverage patterns in this area (Table 1 and data not shown). Race/ethnicity was not examined as a covariate because patients were unable to self-identify race/ethnicity in the EHR, leading to incomplete and potentially inaccurate data. An additional strength of this study setting was that Washington State is a universal vaccine purchaser, meaning that the state purchases vaccines at favorable rates and distributes them to providers at no charge [38]. Cost, therefore, was less likely a confounder in the analysis.

This study demonstrated that there was significant room for improvement in reducing the missed vaccination opportunities among adolescents. Because adolescents were more likely to be vaccinated at preventive visits, promoting regular use of preventive care services for adolescents may increase their vaccination rates. However, in addition, all clinical encounters, preventive and nonpreventive, should be considered potential vaccination opportunities. Improved vaccine tracking and screening systems, such as provider prompts through EHR or manual flags by nurses or medical assistants, would enable providers to more easily identify those teenagers eligible for vaccines at all visit types [39]. When an eligible adolescent is identified, a strong provider recommendation for vaccination and concurrent vaccination when indicated would likely further decrease missed vaccination opportunities [18,40]. Scheduling vaccine-only visits for the second and third HPV vaccine doses at the time of initial HPV vaccination may help increase HPV series completion. Further research is needed to explore why missed vaccination opportunities occur and to develop evidence-based strategies effective in reducing missed opportunities with the goal of improving adolescent vaccination coverage.

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