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REDUCTION OF HPV INFECTIONS THROUGH VACCINATION AMONG AT-RISK URBAN ADOLESCENTS

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Abstract

Introduction—Human papillomavirus (HPV) vaccine trials have demonstrated high efficacy in preventing HPV infections and HPV related disease in females ages 16–26. However, there is no source data to demonstrate the impact of the vaccine in other populations who may be at higher risk for HPV related disease. This study examines the impact of HPV vaccination on subsequent HPV detection and sexual behaviors among urban adolescents in a clinical setting.

Methods—A cohort of adolescent women, ages 14 to 17, were recruited prospectively and matched to historical controls to assess the impact of HPV vaccination. All women completed the same questionnaire and face-to-face interview that assessed sexual behaviors; all provided a clinician or self-collected vaginal swab that was used to test for sexually transmitted infections, including HPV. Logistic regression models, incorporating random pair effects, were used to assess the impact of the HPV vaccine on HPV detection and sexual behaviors between the two groups.

Results—Each woman recruited (N=75) was matched to 2 historical controls (HC); most of the recruited women (89.3%) had received one or more doses of the HPV vaccine. At enrollment, detection of quadrivalent vaccine types (HPV 6, 11, 16 and 18) was significantly less in the recruited group (5.3%) as compared to the HC (24%): OR=5.6 (CI=1.9, 16.5), p=.002. Adolescent women in the HC had a 9.5 times greater odds of HPV infection when the analysis was adjusted to compare those who had 2 or more vaccine doses to their matched controls. The only behavioral difference found was that the recruited women used condoms more frequently.

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GDZ: Investigator on research projects funded by Merck & Co.'s Investigator-Initiated Studies Program

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MLS: Clinical Investigator (Merck & Co.) for HPV related vaccine trials

Conclusion—This study demonstrates that HPV vaccination was associated with fewer vaccine-type HPV infections despite incomplete vaccination and high risk sexual behaviors. These data also suggest that sexual behaviors were not altered because of the vaccine.

Keywords

Human papillomavirus vaccination; human papillomavirus infection; adolescent

1.0 Introduction

Human papillomavirus (HPV) vaccine trials have demonstrated that the vaccines have excellent efficacy against HPV infection and HPV-related cervical disease due to vaccine types in females ages 16 to 26 years, with clinical efficacy greatest in those subjects who were naïve to the vaccine types [1–4]. Clinical trials have demonstrated this efficacy with both the quadrivalent vaccine, which protects against high risk types HPV 16 and 18 and low risks types 6 and 11, and the bivalent vaccine, which protects against HPV 16 and 18. Because HPV is not a reportable infection and now that the vaccine is approved for clinical use, there are no immediate data sources to demonstrate the impact of the vaccine in other populations. The demonstrated efficacy of HPV vaccine in clinical trials was in women 15 to 25 years old (mean age of participants was approximately 20–23 years) with negative serology and negative DNA testing for HPV vaccine types, no history of abnormal cervical cytology, a limited number of lifetime sexual partners, few sexually transmitted infections, and who had completed the 3-dose vaccine series [1–4]. However, by age 14 in the United States, 13.1% of females under 15 years old have had sexual intercourse and by age 19 that rate increases to 70.6% [5]. Furthermore, epidemiological studies demonstrate that acquisition of any HPV infection occurs soon after the initiation of sexual activity [6, 7]. Thus the effectiveness of the vaccine among slightly younger populations with variable access to the vaccine and high sexual risk behaviors is still relatively unknown within health care settings.

High rates of sexually transmitted infections (STIs), including HPV, and documented sexual behaviors have been reported in a longitudinally followed cohort of urban adolescent women recruited from 1999 to 2005 [8–11]. This cohort was recruited prior to HPV vaccine availability. We recently recruited a similar sample of adolescent women within the same clinics, after licensure of the HPV vaccines, to better understand maternal and daughter factors related to HPV vaccine uptake after the introduction of the quadrivalent HPV vaccine into these clinics. These two cohorts provided an opportunity to examine the impact of HPV vaccination on HPV acquisition and obtain preliminary data assessing whether vaccination was associated with changes in sexual behaviors in a high-risk group of adolescent women. Our hypothesis was that compared to the unvaccinated cohort, the vaccinated women would demonstrate lower prevalence of HPV infections despite incomplete vaccination.

2.0 Methods

2.1 Study Participants

In comparing the two cohorts, we used case-matching to minimize potential differences between the groups. The cohort used for selecting matched cases was recruited from the longitudinal study that assessed risk and protective factors for sexually transmitted infections, known as the Young Women's Project (YWP)[8, 11]. Recruitment for the YWP began in the fall 1999 and ended in July 2005. The YWP research protocol was approved by the Institutional Review Board at Indiana University School of Medicine. Adolescent women attending one of three urban primary care clinics in Indianapolis were eligible for

enrollment in this study. Inclusion criteria for the comprehensive study (as well as for the post-vaccination cohort) were as follows: age of 14 to 17 years, able to understand English, not pregnant, and no serious psychiatric problems or mental deficiencies. Both sexually active (vaginal intercourse) and non-sexually active adolescents were enrolled. Participant written informed consent and parental written permission were obtained at enrollment. All participants received financial compensation for their time and effort. All participants completed a written questionnaire that assessed sexual behaviors for the one-year period prior to enrollment and a face-to-face interview that assessed sexual behaviors including frequency of sexual activity, condom use, and partners within the last 2 months. All participants had a clinician obtained or a self-collected vaginal swab that was used to test for sexually transmitted infections (STI), including HPV. None of the women of YWP were vaccinated for HPV during the study observation.

The post-vaccination, prospective cohort (PC) of adolescent women was recruited in the same manner as the YWP. Recruitment took place in 2010 for a one-time visit from the same three metropolitan urban city clinics. At the time of recruitment, the HPV vaccination status was unknown to the study personnel, but quadrivalent vaccine was available to the PC participants and routinely offered to female adolescent clinic patients. The PC research protocol was approved by the university's IRB and written informed consent and permission were obtained from the adolescents and their parents, respectively. Women at the time of enrollment completed the same YWP questionnaire and face-to-face interview that assessed sexual behaviors. HPV vaccination status was verified through clinical records after enrollment. Each participant also provided a self-obtained vaginal swab that was used to test for sexually transmitted infections, including HPV.

2.2 Sample Testing

Dry cervical and vaginal samples were transported to the laboratory where they were vortexed in a tube containing 1 mL of sterile water. An aliquot was used for STI testing using polymerase chain reaction (PCR) assays. STI analysis for *C. trachomatis* and *N. gonorrhoeae*, were performed using the AMPLICOR® CT/NG (Roche Diagnostics, Indianapolis, IN) PCR assay. *T. vaginalis* assay is done using a modified AMPLICOR kit. The remaining vortexed solution was subsequently stored at -20°C until processing for HPV testing.

For HPV testing and genotyping, DNA was extracted from stored samples using QIAamp MinElute Media Kit (Qiagen Inc., Germantown, MD) as previously described [12, 13]. Amplification reactions were then performed on extracted samples using a PerkinElmer TC 9600 Thermal Cycler (PerkinElmer, MA) as done in previous studies [14, 15]. A positive control reaction (sample provided by Qiagen) and a negative control reaction (no DNA) were performed with each assay. The GH20/PC04 human beta-globin target was co-amplified to determine sample adequacy.

The Linear Array HPV Genotyping Test (Roche Molecular Diagnostics, Indianapolis, Indiana) (LA-HPV) was used for HPV detection and genotyping [12, 13, 16]. This assay detects 37 HPV types using 5' biotin-labeled primer pools for PCR amplification within the L1 region of the HPV genome. Detection of specific HPV types was performed after the PCR product was denatured and hybridized onto a Roche paper strip containing 39 BSA-conjugated probes, representing the 37 HPV genotypes and two concentrations of the beta-globin control probe. Post hybridization, streptavidin-alkaline phosphatase conjugate was added to permit identification of hybridized HPV sequences found on the test strip [16, 17]. LA-HPV is an expanded version of an older generation Roche line blot assay used in our prior longitudinal analysis of the same cohort (YWP). Thirty seven individual HPV types were detected in the assay.

2.3 Study Design/Statistical Analysis

Each of the 75 women recruited into the PC were matched with 2 women selected from the 387 YWP participants on age at enrollment, clinic site and reported sexual activity ("yes" versus "never" to self-reported vaginal intercourse) at the time of enrollment. The 150 women (from the YWP) are referenced from here on as the Historical Controls (HC). Summary statistics of the demographics, clinical and behavioral characteristics of the study participants were provided including the baseline STI and HPV prevalence as well as vaccine status of the prospective cohort. Logistic regression models, incorporating random pair effects, were used to assess the impact of HPV vaccination on STIs, HPV detection, and sexual behaviors between the non-vaccinated and HPV vaccinated cohorts.

3. Results

Average age at enrollment of the PC was 15.5 years (SD=1.1) and 88% of the PC adolescents were African-American. Close to 75% of the PC adolescents had a history of sexual intercourse at enrollment with a mean number of sexual lifetime partners of 2.6 (SD=3.5). The mean age of first sex was 13.9 years (SD=1.34). Medical records of the PC verified that 8 (10.7%) adolescents had not received any doses of the HPV vaccine, 8 (10.7%) had one vaccine dose, 10 (13.3%) had two vaccine doses, and 49 (65.3%) completed the series with three vaccine doses. Of the 59 girls with 2 HPV vaccine doses, 16 (27.1%) reported first sex prior to the first documented vaccine dose.

Table 1 compares behavioral and demographic characteristics of the PC to the total YWP sample. Similar to the PC, YWP participants' average age at enrollment was 15.3 (SD 1.1) years and the majority was African American (89.9%). Reported sexual activity at enrollment in the YWP was similar to the PC with 295 women (76.2%) reporting sexual activity and a mean age at first sex of 14.2 years. Reported lifetime partners at enrollment (Mean =3, SD=4) was slightly higher than the PC (Mean =2.6, SD=3.5). No statistical differences were seen in the demographics or behavioral characteristics reported. None of the adolescents in YWP received the HPV vaccine at or before enrollment.

When comparing the PC (n=75) to the matched HC group (n=150) [Table 2] differences were found for HPV detection. Overall, there were no differences in the total number of type specific HPV infections detected at the time of enrollment between the two cohorts. However, detection of quadrivalent vaccine types was significantly less in the PC (5.3%) as compared to the HC (24%) [$p=0.002$] and this was also demonstrated for the two HR vaccine types, 16 and 18. Adolescent women in the HC had a 5.6 times greater odds of infection of HPV 6, 11, 16, and 18 than the PC. When the analysis was adjusted to compare those who had 2 or more vaccine doses to their matched controls, there was a 9.5 times greater odds of HPV infection of vaccine covered types compared to girls in the PC. Instances of vaginal intercourse without a condom (over the last 2 months) were significantly lower in the PC (vaccinated) as compared to those in the HC (unvaccinated) [$p<.001$]. This was the only sexual behavior found to be different between the two cohorts. No differences were found in chlamydia and trichomonas rates between the unvaccinated and vaccinated cohorts. The number of gonorrhea infections was too small to evaluate differences between the matched cohorts.

²6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51, 52, 53, 54, 55, 56, 58, 59, 61, 62, 64, 66, 67, 68, 69, 70, 71, 72, 73, 81, 82, 83, 84, CP6108, and IS39

4. Discussion

This study demonstrates that vaccination of adolescent females was associated with fewer vaccine-type HPV infections, suggesting that the quadrivalent vaccine was very effective, even in the context of high risk behaviors and variable HPV vaccine completion. As expected the impact of vaccination was strongest for those with two or more doses of the vaccine [18]. Given the characteristics of the cohorts, higher risk sexual behaviors and minority women, these results suggest great potential for the HPV vaccines for women at highest risk for future HPV-related diseases, including cervical cancer. The prevalence of HPV, particularly in the HC, was high and comparable to another study of young women with similar demographics [19]. The HPV prevalence was much higher than a national cross sectional prevalence study of similar age adolescents [20]. Our higher HPV rates were expected with a cohort that has earlier onset of first sex and multiple partners and therefore supports the need for enhanced public health messages about HPV vaccination and vaccine completion within low-income, minority young women.

Instances of vaginal intercourse without condom use were significantly less in the PC, which provides evidence that sexual behaviors were not altered (in the direction of increased risk) after receiving the HPV vaccine. As reported there were no differences in other sexual-risk factors, such as number of sexual partners in the last year, number of recent sexual partners (last 2 months) and STIs at enrollment, including the most commonly seen bacterial STI, chlamydia. Parents have reported being concerned that the vaccine may alter young women's sexual behavior [21, 22] given that the vaccine is targeted at a sexually transmitted infection (STI). The notion of HPV vaccination leading to behavioral disinhibition has been a concern expressed by only a minority of parents and/or adolescents found in surveys addressing attitudes and beliefs [23–25]. One such survey had documented a higher belief in disinhibition in low income minority adolescents [25]. Two recently-published research studies found no evidence for behavioral disinhibition after HPV vaccination [26, 27]. Our findings also provide evidence that sexual behaviors may not change with vaccination status.

Although this was a small study, the advantages of the historical case control methodology and documented records of HPV vaccination study give strength to our study findings and allow comparison of a vaccinated versus unvaccinated cohort. The largest limitation of the study design was the temporal separation of the two cohorts (almost 10 years) and thus we cannot totally exclude the possibility that some other external factor not measured may have contributed to the findings of reduced HPV detection of the quadrivalent HPV types or the observations in sexual behaviors. As presented, condom use was greater in the PC. This finding is consistent with increasing rates of condom use seen nationally [28]. Increased condom use may have also been explained if HPV vaccination provides an opportunity for increased conversations between provider and the adolescent and/or parent about sexual behaviors. Finally, more consistent condom use may have been responsible for the lower rates of HPV seen in the PC. However, given the lack of clarity about the extent to which condoms protect against HPV [29], we suspect that higher rates of condom use in the PC had a limited role in reducing HPV infections. This conclusion is supported in our findings that lower rates of other sexually transmitted infections were not seen in the PC which would have been expected with lower instances of unprotected sex.

5. Conclusion

We found that the HPV vaccine was effective for younger, higher risk adolescents, who were recruited from a clinical setting and had variable rates of completion of vaccination. This study continues to support the need for early and catch-up vaccination in all adolescent and young adult women and serves to remind clinicians and parents that vaccination should

be targeted for all at 11 to 12 years of age to maximize its impact rather than waiting until the adolescent is older. In addition, we found evidence that the vaccine did not increase sexual risk behaviors. This evidence, however, is somewhat limited and larger prospective studies may help further to understand whether, and in what way, HPV vaccination influences sexual behaviors.

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Abbreviations

YWP	Young Women's Project
HC	Historical Controls
PC	Prospective Cohort

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Highlights

We examined the impact of HPV vaccination on HPV acquisition in a clinical setting.

Adolescent women were recruited prospectively and matched to historical controls.

Sexual risk behavior profiles were similar between the two groups.

Detection of HPV 6, 11, 16 and 18 was significantly less in the vaccinated group.

Table 1

Comparison of the YWP Cohort (N=387) and Prospective Cohort (N=75)

Variable	YWP	PC	(p-value)
Average age at enrollment	15.3 year	15.5 years	0.23
Black race, N (%)	347 (89.9)	66 (88)	0.17
Sexually active at enrollment, N (%)	294 (76.2)	55 (73.6)	0.65
Average age of reported 1 st sex	14.2 years	13.9 years	0.62
Reported lifetime partners at enrollment, N (SD)	3 (4)	2.6 (3.5)	0.63
One or more doses of HPV vaccine, N (%)	0 67	(89.3)	<.01 *
Two or more doses of HPV vaccine, N (%)	0 59	(78.7)	<.01 *

* Calculated with Fisher's Exact Test

Table 2

Matched analysis comparing the Historical Control (HC) and the Prospective Cohort (PC)

Variable	HC (N=150)	PC (N=75)	OR (95% CI)	p-value
Mean number of sex partners over the last year (SD)	2.84 (4.08)	2.57 (3.52)	1.1 (0.9, 1.3)	NS
Mean number of sex partners last 2 months (SD)	1.44 (1.22)	1.19 (0.87)	1.2 (0.9, 1.5)	NS
Mean instances of vaginal intercourse last 2 months (SD)	4.72 (5.29)	5.22 (11.2)	1.0 (0.9, 1.2)	NS
Mean instances of vaginal intercourse without a condom last 2 months (SD)	3.8 (11.1)	1.8 (3.9)	0.5 (0.4, 0.6)	0.001
Gonorrhea, N (%)	6 (4%)	0 (0%)	--	--
Chlamydia, N (%)	17 (11.3)	9 (12.0%)	0.9 (.04, 2.2)	NS
Trichomonas, N (%)	10 (6.7%)	1 (1.3%)	5.3 (0.7, 42.3)	NS
Any high risk HPV types, N (%)	62 (41.3%)	25 (36.0%)	1.3 (0.7, 2.2)	NS
Any low risk HPV types, N (%)	50 (33.3%)	29 (28.7%)	0.8 (.04, 1.4)	NS
HPV 6, 11, 16, 18; N (%) [*]	34 (24.0%)	4 (5.3%)	5.6 (1.9, 16.5)	0.002
HPV 16 and 18, N (%)	25 (16.7%)	4 (5.3%)	3.6 (1.2, 10.6)	0.025

^{*} When prospective cohort was limited to the 59 who received 2 doses, the OR increases to 9.5 (CI =2.2, 41.6), p=0.03.