Factors associated with parental human papillomavirus vaccination intentions among adolescents from socioeconomically advantaged versus deprived households: a nationwide, cross-sectional survey

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Summary

Background In the USA, HPV vaccine coverage is substantially lower among adolescents from high-income households compared to their low-income counterparts. We examined and compared the factors associated with parental HPV vaccination intentions between socioeconomically divergent groups.

Methods Data from unvaccinated and not fully HPV-vaccinated adolescents from the 2017–2021 National Immunization Survey (NIS)-Teen were analyzed. Socioeconomically advantaged vs. deprived groups were identified based on dichotomized income (material capital) and education (social capital). Parental intent to initiate and complete the HPV vaccine series was compared using bivariable analysis and the factors associated with lacking intent were identified.

Findings The 2017–2021 NIS-Teen included a total of 212,643 participants; the final analytical sample consisted of 105,958 adolescents (an estimated 10.3 million adolescents) who were unvaccinated or not fully vaccinated. In the advantaged group, 64.7% of parents of unvaccinated adolescents (equating to 2.4 million US adolescents) had no intention to initiate the HPV vaccine compared to 40.9% of parents in the deprived group (equating to 0.2 million adolescents) ($P < 0.0001$; $S > 13.29$). The most frequent reason for lacking intent in the advantaged group was 'safety concerns' (25.5%). In the deprived group, 'lack of knowledge', 'not recommended', and 'not needed' were common reasons (nearly 15% each). Lack of intent to complete the HPV vaccine series was higher in the advantaged group (43.9%; 1.1 million adolescents) compared to the deprived group (25.2%; 0.08 million adolescents) ($P < 0.0001$; $S > 13.29$). More than half in the advantaged group (58.4%) and over a third (37.1%) in the deprived group cited 'already up to date' as the main reason for not completing the HPV vaccine series.

Interpretation Lack of intent to initiate and complete the HPV vaccination series, particularly among socioeconomically advantaged parents is a significant barrier to achieving the national goal in the USA.

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Keywords: HPV vaccine; Human papillomavirus vaccine; Vaccine hesitancy; Parental hesitancy; Reasons for hesitancy; Socioeconomic status; Socioeconomic advantage; Socioeconomic deprivation

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Research in context

Evidence before this study

In 2023, for the first time since its implementation, human papillomavirus (HPV) vaccine coverage did not improve in the United States of America (USA). Vaccination rates continued to remain suboptimal (62.6% in 2022) and a decline was reported among the recent versus previous birth cohorts, specifically, in those from high-income households and among non-Hispanic White adolescents. Given that HPV vaccination is not mandated in most states, uptake and completion of HPV vaccine series among adolescents largely rely on parental intentions. We searched PubMed for studies published in the last ten years in the English language using the search terms "Parental intent" OR "Parental intention" AND "HPV vaccine" OR "Human papillomavirus vaccine" AND "Socioeconomic status". While a few ecological studies examined the correlation between HPV vaccine uptake and neighborhood socioeconomic status, no previous studies examined whether parental intentions to initiate and complete the HPV vaccine series and the associated factors differ by socioeconomic status (i.e., socioeconomic advantage and disadvantage or deprivation).

Added value of this study

Using data from a nationally representative survey of US adolescents (the adolescent component of the National Immunization Survey [NIS-Teen]), we estimated parental lack of intent to initiate and complete the HPV vaccine series and compared the factors associated with parental lack of intent by socioeconomic status. A high proportion of socioeconomically advantaged parents compared to the deprived parents lack intent to initiate (64.7% vs. 40.9%) and complete (43.9% vs. 25.2%) the HPV vaccine series. Reasons for lack of intent to initiate differed by socioeconomic status. 'Safety concerns' emerged as a major reason for the lack of intent to initiate the vaccine series in the advantaged group. In the deprived group, lack of knowledge, not recommended, and not needed/necessary were cited as common reasons.

Implications of all the available evidence

These data suggest that factors associated with parental lack of intent differ greatly based on their socioeconomic status. Parental HPV vaccine hesitancy is more prevalent among groups with higher socioeconomic status largely driven by unfounded safety concerns. These findings might explain why HPV vaccination coverage in the USA stagnated in recent birth cohorts. Addressing parental concerns and improving vaccine confidence will be critical for achieving the national HPV vaccine goal among US adolescents.

Introduction

In the United States of America (USA), human papillomavirus (HPV) vaccination coverage continues to remain well below the 80% national goal (62.6% in 2022).[1] Notably, in August of 2023 the Centers for Disease Control and Prevention (CDC) reported that for the first time, national HPV vaccine coverage did not improve.[1] Moreover, coverage was significantly lower in adolescents from at or above-income households and among non-Hispanic Whites in recent compared to previous birth cohorts.[1] Historically, differences in HPV vaccine uptake and completion were prominent between socioeconomically divergent groups. Coverage among adolescents with high school or above-educated parents was lower by 14 percentage points compared to their counterparts with below-high school-educated parents in a prior study.[2] In 2021, coverage with ≥1 HPV vaccine dose among adolescents from households at or above-poverty level was nearly 10%-points lower compared to their below-poverty level counterparts.[3] The differences are hypothesized to stem from disparate vaccine attitudes and HPV vaccine beliefs among these socioeconomically divergent groups.[3]

Socioeconomically divergent groups are known to have contrasting views and opinions, and the homophily within groups often results in the formation of social norms, including norms surrounding vaccines.[4–9] Studies have reported that social norms can influence parental attitudes and intentions toward pediatric vaccines.[10,11] The *Increasing Vaccination Model* identifies social norms and vaccine confidence (i.e., perceived vaccine benefits and safety) as key factors that drive motivation (intention or hesitancy) and ultimately uptake of the recommended vaccines.[12,13] In the USA, parental intentions regarding the HPV vaccine for their adolescent child are particularly critical because HPV vaccine mandates for school entry do not exist in most states.[14,15] Persistent and high confidence in the HPV vaccine among parents of adolescents from all socioeconomic backgrounds will be key to continuing to make progress toward the national goal. While some studies have explored parental barriers to HPV vaccine uptake, no prior study has examined parental HPV vaccination intentions and the factors associated with lack of intent among unvaccinated and not fully vaccinated adolescents in the context of divergent socioeconomic groups using a nationally representative sample.[16,17] Our objective was to compare factors associated with the lack of parental HPV vaccination intent between socioeconomically divergent (advantaged versus deprived) groups.

Methods

Study design and participants

We performed a cross-sectional analysis of the 2017–2021 National Immunization Survey-Teen

(NIS-Teen) data. The NIS-Teen is an annual random-digit-dial survey of households with 13–17-year-old adolescents in the USA. Survey samples are independently drawn from households with eligible adolescents using a multi-stage sampling design. The survey data represents the response of one adult caregiver of a 13–17-year-old adolescent child in a given household. A knowledgeable adult (i.e., a parent or caregiver of the adolescent) from the household is interviewed after obtaining verbal informed consent. Parent (or caregiver)-reported sociodemographic information and adolescents' vaccination status were recorded by trained personnel; adolescents may have been vaccinated at any age leading up to the interview. If the adolescents are not fully vaccinated at the time of the survey, the respondents are asked additional questions including their intention to vaccinate their children within the next 12 months and their main reason for not vaccinating (or not fully vaccinating if more than one dose is required) their child. Sampling weight is calculated after adjustment for subsampling and non-response to provide an accurate reflection of this population at the national level. Documentation regarding the survey design and analytical guidelines are available in the Supplementary Material and on the CDC website.[18] The Medical University of South Carolina Institutional Review Board deemed this study exempt from review and informed consent because it used deidentified publicly available data.

Procedures

We identified adolescents who did not initiate or complete the HPV vaccine series at the time of the survey from the 2017–2021 NIS-Teen survey data. The primary outcome was the lack of parental intent to initiate or complete the HPV vaccine series for an adolescent, therefore, we used the full sample and not the provider-verified sub-sample. Parental HPV vaccine intent was determined based on two sequential questions. The first question was "Has the teen ever received HPV shots?". Respondents who said "no" were 'unvaccinated' and assigned zero for the total number of shots received. If the response was "yes", the total number of HPV vaccine doses received by the adolescent was recorded. If the adolescent had received zero doses of the HPV vaccine or had not completed the HPV vaccine series, then the respondent was asked "How likely is it that the teen will receive any/all HPV shots in the next 12 months?". Answers were recorded on a 5-point Likert Scale including "very likely", "somewhat likely", "not too likely", "not likely at all", and "not sure/don't know". Participants with responses "not too likely" or "not likely at all" were identified as lacking intent to HPV vaccinate; otherwise, "very likely" and "somewhat likely" were coded as intending to HPV vaccinate. The outcome (lack of parental HPV vaccination intent) was coded as *0*/*1*, where *1* included parents of adolescents who responded their children were "not too likely" or "not likely at all" to receive the HPV vaccine in the next 12 months; *0* otherwise. Our main analyses examined differences in parental intent to initiate the vaccine series for an unvaccinated adolescent by socioeconomic position; we also examined differences in intent to complete the vaccine series among parents of not fully vaccinated adolescents.

The main predictor of interest was the socioeconomic position of the parent (and their adolescent child). The variable is calculated as the sum of two dichotomized variables—1) household income-to-poverty ratio (*0* = below or equal to 200% of the federal poverty level (FPL); *1* = above 200% of the federal poverty level), and 2) educational attainment (*0* = less than high school; *1* = high school or above) for each participant in the study.[19] This yields a discrete variable of possible values *0*, *1*, and *2*, where '*0*' indicates the deprived group (i.e., below 200% FPL and less than a high school education), '1' indicates the disadvantaged group (i.e., either income below 200% FPL or less than a high school education), and '*2*' indicates the advantaged group (i.e., above the 200% FPL and high school or more years of education).[20] In the US, income (which captures material capital) and education (which captures social capital) are strong proxies for socioeconomic position, and the two variables reportedly dominate all other relevant measures of social status.[21] Prior studies have used similar approaches for exploring the association between socioeconomic status and health outcomes.[20,22–24] In the main analyses, we examined and compared parental lack of intent in the advantaged and deprived groups.

Information on the adolescents' age, sex, race/ethnicity, state of residence, insurance status, mother's education level, household income, provider HPV vaccine recommendation, and housing tenure are self-reported by the adult respondents. Certain state/local laws require HPV vaccination for school entry; therefore, HPV vaccine mandate (Yes/No) was examined as an independent variable to capture parental lack of intent in these subsets. The region of residence and school-entry mandate for HPV vaccination were identified based on the region and state of residence of adolescents reported in the survey. Reasons for lack of intention to vaccinate were identified from the question "What is the main reason the teen will not receive any (all) HPV shots in the next 12 months?" Parents selected the main reason from a list of predefined reasons; if unlisted, the response was elicited in an open-ended manner. In the final dataset, all reasons were recorded into 28 unique yes or no questions by the NIS-Teen staff.

Statistical analysis

The main outcome of interest, i.e., parental intention for HPV vaccination, was compared between the

advantaged (highest) versus the deprived (lowest) socioeconomic groups. Descriptive statistics (weighted proportions, weighted frequencies, and unweighted frequencies) were used to present the characteristics of the two groups, and the differences were examined using the survey-weighted Wald's F test (categorical variables). The survey-weighted proportions and respective 95% confidence intervals for parental lack of intent and the main reason for lack of intent were calculated for the two groups. Pairwise differences were tested using the Wald F test. Multivariable logistic regression analyses adjusting for age group, sex, race/ethnicity, housing tenure, state mandate, provider recommendation, and region of residence were performed to determine the overall and race/ethnicity stratified odds for parental lack of intent (Yes/No) to vaccinate between participants from socioeconomically advantaged versus deprived (referent group) households. A series of sensitivity analyses were performed—1) proportion lacking intent in all three socioeconomic groups (deprived, disadvantaged, and advantaged) was determined, 2) odds for parental lack of intent by socioeconomic status were determined before and during the coronavirus (COVID) pandemic, 3) parental lack of intent was modeled as an ordinal outcome, and 4) the odds ratio for parental lack of intent were examined by deconstructing the socioeconomic groups by income and education levels. All analyses were restricted to participants with non-missing data for the outcome of interest and were adjusted for strata, clusters, and weights using the SAS survey procedures to account for the complex survey design. A total of 62,718 unvaccinated and 43,240 not fully vaccinated adolescents were included in the final analytical sample. Information on home ownership (3.2% in both unvaccinated and not fully vaccinated adolescents) and provider recommendations (4.0% unvaccinated and 1.4% not fully vaccinated adolescents) was missing. Statistical significance was tested at $P < 0.05$. Compatibility was examined using S-values; the S-value is scaled in *bits* (binary digits) of information with a higher S value suggesting better compatibility.[25] At a P of 0.05, compatibility is interpreted as the probability of obtaining at least 4.3 bits of information against the model. All analyses were performed according to the analytical guideline for the NIS-Teen data using the SAS statistical software (version 9.4).[18]

Results

A total of 212,643 participants, representative of over 20.9 million US adolescents, were identified from 2017 to 2021 NIS-Teen (Supplementary Figure S1). The final analytical sample consisted of 105,958 participants (an estimated 10.3 million adolescents). Of these, a total of 62,718 participants (estimated 6.2 million adolescents) were unvaccinated—0.5 million deprived, 1.9 million disadvantaged, and 3.8 million advantaged adolescents. In addition, 43,240 (estimated 4.1 million) adolescents were not fully vaccinated—0.3 million deprived, 1.2 million disadvantaged, and 2.6 million advantaged adolescents. Characteristics of the unvaccinated and not fully HPV-vaccinated adolescents are presented in Supplementary Tables S1 and S2, respectively.

In the advantaged group, 64.7% (2,479,707 of 3,834,966) of parents of unvaccinated adolescents lacked the intent to initiate the HPV vaccine series compared to 40.9% (210,442 of 514,388) among the deprived group ($P < 0.0001$; $S > 13.29$) (Fig. 1A). Among those who were not fully vaccinated, 43.9% (1,130,418 of 2,572,090) in the advantaged group lacked the intent to complete the vaccine series compared to 25.2% in the deprived group (81,887 of 325,517) ($P < 0.0001$; $S > 13.29$) (Fig. 1B).

The most frequently cited reason for parental lack of intent among unvaccinated adolescents is presented in Fig. 1C. In the advantaged group, 'safety concern/side effects' (25.5%; 605,241 of 2,374,229) was cited most frequently by parents for not initiating the vaccine series. In comparison, lack of knowledge (30,669 of 191,665), safety concerns/side effects (28,439 of 191,665), not recommended (27,741 of 191,665), and not needed or necessary (27,506 of 191,665) contributed nearly 15% each to a lack of intent in the deprived group. Reasons for the lack of intent to complete the HPV vaccine series are presented in Fig. 1D. More than half (58.4%; 601,095 of 1,029,137) of the parents in the advantaged group and over a third (37.1%; 25,454 of 68,681) in the deprived group cited 'already up to date' as the main reason for not completing the HPV vaccine series. A complete list of reasons and the respective proportions of parents citing those reasons are available in Supplementary Table S3.

The lack of intention in advantaged and deprived groups by sociodemographic stratum is presented in Table 1. The proportion of parents lacking the intent to initiate the HPV vaccine series was higher in the advantaged group across age, sex, race/ethnicity, housing tenure, and insurance strata except for 'other' race/ethnicity and privately or 'other' insured adolescents. Lack of intent in the advantaged group was higher regardless of HPV mandate status in the state of residence of participants or by provider recommendation history. Except for the 13-14-year-old adolescent age group, the lack of intention to complete the vaccine series in the advantaged group was higher compared to the deprived group in nearly all sociodemographic strata.

In sensitivity analysis, parental lack of intent to initiate the HPV vaccine series was highest in the advantaged group (64.7%; 2,479,707 of 3,834,966) followed by the disadvantaged group (58.1%; 1,249,399 of 1,851,415) and then the deprived group (40.9%; 210,442 of 514,388) ($P < 0.0001$; $S > 13.29$) (Fig. 2). Similarly, parental lack of intent to complete the HPV vaccine series for their not fully vaccinated adolescent was

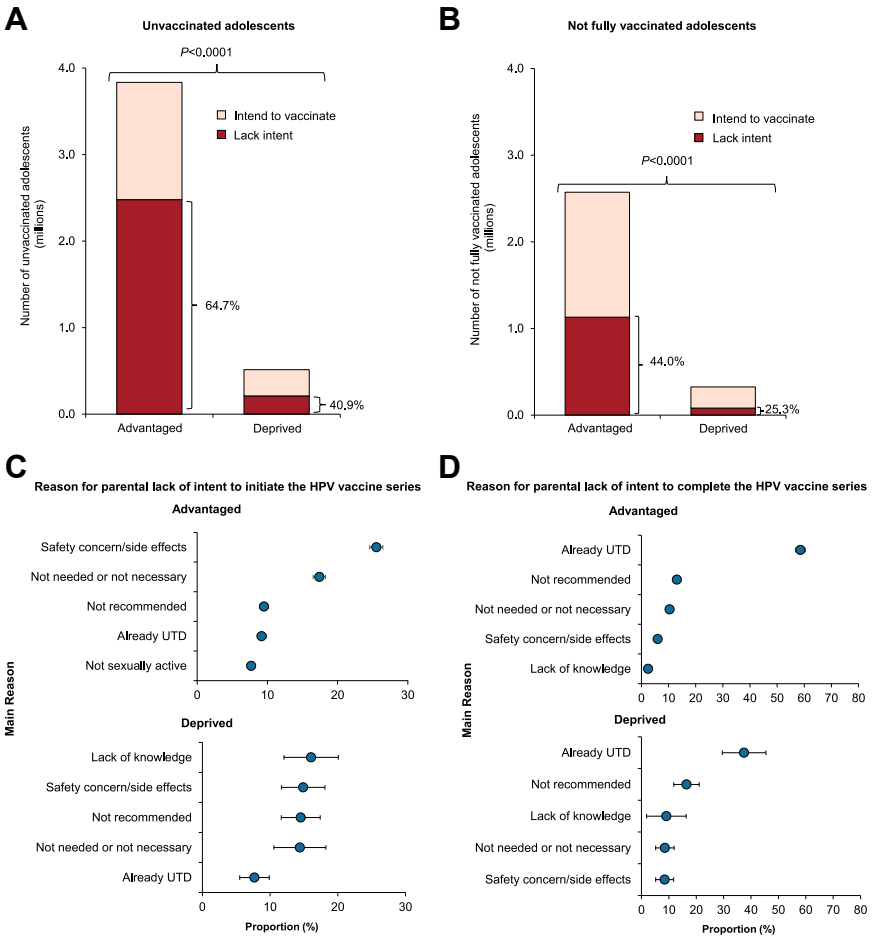

Fig. 1: **Parental lack of intent and reasons for lack of intent to initiate and complete the HPV vaccine series in the advantaged and deprived group, NIS-Teen 2017–2021.**[a] Figure illustrates the estimated population size of unvaccinated (**PANEL A**) and not fully vaccinated (**PANEL B**) adolescents and the proportion of parents lacking the intent to initiate and complete the HPV vaccine series, respectively. The top five reasons for the lack of parental intention to initiate (**PANEL C**) and complete (**PANEL D**) the HPV vaccine series in the advantaged and deprived groups are also listed. Abbreviations: HPV, human papillomavirus; NIS, National Immunization Survey; UTD, Up to date [a]Lack of parental intent to initiate the vaccine series was determined based on response to the question "*How likely is it that the teen will receive any HPV shots in the next* 12 months?" The main reason for the lack of intention to initiate the vaccine series was based on a response selected from a pre-defined list of reasons accompanying the question "*What is the main reason teens will not receive any HPV shots in the next* 12 months?" [a]Lack of parental intent to complete the vaccine series was determined based on response to the question "*How likely is it that the teen will receive all HPV shots in the next* 12 months?" The main reason for the lack of intention to complete the vaccine series was based on a response selected from a pre-defined list of reasons accompanying the question "*What is the main reason teens will not receive all HPV shots in the next* 12 months?". The population estimates were derived from NIS-Teen survey weights. Proportion represents survey-design adjusted and weighted estimates derived using the weights for the full sample. Error bars represent 95% confidence intervals.

highest for the advantaged (43.9%; 1,130,418 of 2,572,090) group, followed by disadvantaged (36.2%; 452,493 of 1,249,399) and deprived (25.2%; 81,887 of 325,517) groups ($P < 0.0001$; $S > 13.29$). Findings by sociodemographic stratum are in Supplementary Tables S4 and S5.

Multivariable regression models accounting for confounders (Supplementary Figure S2) suggest that the odds of lacking intent for initiating the HPV vaccine series for their unvaccinated child in the advantaged group were higher [1.92 (95% CI, 1.66–2.21); $S > 13.29$] compared to the deprived group (Table 2). For lack of intent to complete the vaccine series, overall, the odds for lack of parental intent were higher in the advantaged compared to the deprived group (aOR, 1.91; 95% CI, 1.55–2.35; $S > 13.29$). Findings for advantaged vs. deprived groups were consistent in sensitivity analyses (Supplementary Tables S6 and S7).

Stratified by race/ethnicity, the odds for parental lack of intent to initiate the HPV vaccine series (advantaged

Characteristics	Parental lack of intent (Unvaccinated)					Parental lack of intent (Not fully vaccinated)				
	Deprived		Advantaged		*P*[a] and S	Deprived		Advantaged		*P*[a] and S
	n/N unweighted; estimated population size	Weighted % (95% CI)	n/N unweighted; estimated population size	Weighted % (95% CI)		n/N unweighted; estimated population size	Weighted % (95% CI)	n/N unweighted; estimated population size	Weighted % (95% CI)	
Total	1618/3887; 210,442/514,388	40.9 (38.0–43.8)	27,240/42,473; 2,479,707/3,834,966	64.7 (63.8–65.5)	<0.0001 >13.29	654/2612; 81,887/325,517	25.2 (21.9–28.4)	13,053/29,857; 1,130,418/2,572,090	43.9 (42.9–45.0)	<0.0001 >13.29
Age										
13–14 years	656/1700; 82,636/221,338	37.3 (33.1–41.6)	10,884/18,601; 1,003,782/1,677,859	59.8 (58.6–61.1)	<0.0001 >13.29	189/982; 23,785/121,570	19.6 (13.7–25.4)	2390/9753; 201,758/827,784	24.4 (22.9–25.9)	0.12 3.06
15–17 years	962/2187; 127,806/293,051	43.6 (39.7–47.6)	16,356/23,872 1,475,925/2,157,108	68.4 (67.3–69.5)	<0.0001 >13.29	465/1630; 58,103/203,948	28.5 (24.6–32.4)	10,663/20,104; 928,660/1,744,306	53.2 (52.0–54.5)	<0.0001 >13.29
Sex										
Male	902/2163; 119,032/280,926	42.4 (38.3–46.4)	15,446/24,046; 1,373,248/2,111,735	65.0 (64.0–66.1)	<0.0001 >13.29	322/1294; 40,181/159,528	25.2 (20.6–29.8)	6585/15,377; 554,838/1,284,689	43.2 (41.7–44.7)	<0.0001 >13.29
Female	716/1724; 91,410/233,462	39.2 (35.0–43.3)	11,794/18,427; 1,106,459/1,723,231	64.2 (63.0–65.5)	<0.0001 >13.29	332/1318; 41,706/165,990	25.1 (20.6–29.7)	6468/14,480; 575,581/1,287,401	44.7 (43.2–46.2)	<0.0001 >13.29
Race/ethnicity										
NH White	533/891; 62,168/102,259	60.8 (55.6–66.0)	20,047/30,470; 1,709,061/2,561,808	66.7 (65.8–67.6)	0.02 5.64	197/532; 21,373/57,921	36.9 (30.6–43.2)	9314/20,728; 738,719/1,634,763	45.2 (44.0–46.4)	0.02 5.64
NH Black	134/327; 21,062/50,284	41.9 (33.9–49.9)	1868/3118; 243,239/390,846	62.2 (59.4–65.0)	<0.0001 >13.29	53/260; 7590/40,989	18.5 (10.8–26.2)	931/2426; 112,297/288,738	38.9 (35.8–42.0)	<0.0001 >13.29
Hispanic	804/2369; 110,700/329,325	33.6 (29.8–37.4)	2688/4509; 310,219/518,575	59.8 (56.9–62.7)	<0.0001 >13.29	345/1632; 48,030/208,460	23.0 (18.6–27.5)	1387/3366; 156,977/370,003	42.4 (38.7–46.1)	<0.0001 >13.29
Other	147/300; 16,513/32,520	50.8 (40.7–60.8)	2637/4376; 217,187/363,737	59.7 (56.9–62.5)	0.10 3.32	59/188; 4894/18,147	27.0 (17.4–36.5)	1421/3337; 122,425/278,586	43.9 (40.6–47.3)	0.003 8.38
HPV vaccine mandate[b]										
Yes	65/184; 3715/9344	39.8 (21.6–57.9)	1084/1864; 71,217/108,255	65.8 (61.3–70.3)	0.01 6.64	20/121; 1332/7728	17.2 (2.1–32.4)	933/2241; 38,169/96,101	39.7 (35.0–44.5)	0.03 5.75
No	1553/3703; 206,727/505,044	40.9 (38.0–43.9)	26,156/40,609; 2,408,490/3,726,712	64.6 (63.8–65.5)	<0.0001 >13.29	634/2491; 80,555/317,789	25.3 (22.0–28.7)	12,120/27,616; 1,092,249/2,475,989	44.1 (43.0–45.2)	<0.0001 >13.29
Housing tenure										
Rent	849/2284; 112,532/313,562	35.9 (32.2–39.6)	3495/5770; 353,174/574,491	61.5 (59.1–63.8)	<0.0001 >13.29	350/1556; 45,946/210,342	21.8 (18.1–25.6)	1410/3595; 149,852/363,233	41.3 (38.0–44.5)	<0.0001 >13.29
Own	661/1364; 83,836/168,821	49.7 (44.7–54.6)	23,125/35,791; 2,067,706/3,176,492	65.1 (64.2–66.0)	<0.0001 >13.29	262/895; 28,441/94,741	30.0 (24.1–35.9)	11,397/25,676; 953,304/2,152,813	44.3 (43.2–45.4)	<0.0001 >13.29
Insurance										
Private	75/137; 7405/13,044	56.8 (44.9–68.7)	7709/13,032; 687,613/1,159,241	59.3 (57.8–60.9)	0.68 0.56	26/90; 5818/15,340	37.9 (10.8–65.1)	5078/11,943; 415,840/994,232	41.8 (40.2–43.5)	<0.0001 >13.29
Medicaid	448/1219; 56,742/162,797	34.9 (29.9–39.8)	1098/1776; 101,856/164,376	62.0 (58.1–65.9)	<0.0001 >13.29	240/1059; 29,966/128,453	23.3 (18.6–28.1)	539/1367; 48,210/121,664	39.6 (34.7–44.6)	<0.0001 >13.29
Other	44/107; 5586/11,942	46.8 (29.1–64.5)	940/1566; 75,760/118,282	64.1 (60.3–67.8)	0.09 3.47	28/106; 2820/11,444	24.6 (11.1–38.2)	484/1136; 40,903/88,998	46.0 (40.6–51.3)	<0.0001 >13.29
Uninsured	92/246; 12,523/27,655	45.3 (34.5–56.1)	288/434; 29,777/41,102	72.5 (65.4–79.5)	<0.0001 >13.29	32/159; 3844/14,533	26.4 (13.2–39.7)	84/232; 10,392/23,202	44.8 (30.9–58.7)	<0.0001 >13.29
Region										
Northeast	199/520; 23,895/56,584	42.2 (35.8–48.7)	4252/7116; 380,592/604,427	63.0 (61.3–64.7)	<0.0001 >13.29	93/400; 11,248/43,879	25.6 (18.9–32.3)	2671/6348; 198,041/466,593	42.4 (40.5–44.4)	<0.0001 >13.29
Midwest	306/688; 44,286/91,636	48.3 (43.2–53.5)	5887/8874; 567,888/857,610	66.2 (64.9–67.6)	<0.0001 >13.29	121/431; 15,915/52,973	30.0 (24.0–36.1)	2852/6428; 250,840/581,785	43.1 (41.4–44.8)	<0.0001 >13.29

(Table 1 continues on next page)

Characteristics	Parental lack of intent (Unvaccinated)					Parental lack of intent (Not fully vaccinated)				
	Deprived		Advantaged		P^a and S	Deprived		Advantaged		P^a and S
	n/N unweighted; estimated population size	Weighted % (95% CI)	n/N unweighted; estimated population size	Weighted % (95% CI)		n/N unweighted; estimated population size	Weighted % (95% CI)	n/N unweighted; estimated population size	Weighted % (95% CI)	
(Continued from previous page)										
South	786/1912; 88,806/214,336	41.4 (37.5–45.4)	10,969/17,092; 997,421/1,528,132	65.3 (64.1–66.4)	<0.0001 >13.29	293/1243; 29,406/131,703	22.3 (18.3–26.4)	4785/10,980; 417,846/944,618	44.2 (42.6–45.9)	<0.0001 >13.29
West	327/767; 53,455/151,832	35.2 (28.3–42.2)	6132/9391; 533,806/844,797	63.2 (60.7–65.6)	<0.0001 >13.29	147/538; 25,319/96,963	26.1 (17.8–34.4)	2745/6101; 263,691/579,094	45.5 (42.5–48.6)	<0.0001 >13.29
Provider recommendation for HPV vaccine										
Yes	399/917; 55,329/122,872	45.0 (39.2–50.9)	13,060/20,990; 1,218,205/1,933,430	63.0 (61.9–64.2)	<0.0001 >13.29	562/2227; 72,011/283,690	25.4 (21.9–28.9)	12,419/28,494; 1,072,602/2,447,021	43.8 (42.8–44.9)	0.001 9.96
No	1137/2751; 145,335/364,704	39.9 (36.3–43.4)	13,179/19,847; 1,176,813/1,760,954	66.8 (65.668.1)	<0.0001 >13.29	79/298; 8648/32,585	26.5 (16.4–36.6)	474/1018; 42,596/91,841	46.4 (40.5–52.3)	<0.0001 >13.29

Abbreviations: HPV, Human papillomavirus; NIS, National Immunization Survey; NH, Non-Hispanic. [a]P values for survey design-adjusted Wald F test. [b]HPV vaccine mandate regions include the District of Columbia, Rhode Island, and Virginia. The state of Hawaii was not included as the mandate was implemented in July 2020.

***Table 1:* Parental lack of intent to initiate and complete the HPV vaccine in socioeconomically advantaged and deprived groups, NIS-Teen 2017–2021.**

vs. deprived) were highest in Hispanic (aOR, 2.64; 95% CI, 2.08–3.35; *S > 13.29*) followed by non-Hispanic Black (aOR, 1.97; 95% CI, 1.35–2.90; *S > 13.29*) and Other (aOR, 1.67; 95% CI, 1.04–2.69; *S* = 3.42) subgroups (Fig. 3). Lack of intent to complete the series (advantaged vs. deprived) was highest among non-Hispanic Black (aOR, 2.50; 95% CI, 1.46–4.31; *S* = 12.29), Hispanic (aOR, 2.22; 95% CI, 1.59–3.10; *S > 13.29*), and other (aOR, 2.04; 95% CI, 1.11–3.75; *S* = 3.91) subgroups.

Deconstruction of socioeconomic groups by income and education revealed that the odds for lack of intent to initiate the vaccine series was greater for *above high school education-below 200% FPL income* (aOR, 1.72; 95% CI, 1.50–1.98; *S > 13.29*) and *below high school education-above 200% FPL income* (aOR, 1.45; 95% CI, 1.11–1.88; *S > 13.29*) groups when compared to *below high school-below 200% FPL group* (Supplementary Figure S3). While the odds for lack of intent to complete the vaccine series were greater for *below high school education-above 200% FPL income* group (aOR, 1.61; 95% CI, 1.31–1.20; *S > 13.29*) and *above high school education-below 200% FPL income* group (aOR, 1.76; 95% CI, 1.20–2.58; *S > 13.29*) versus *below high school education and below 200% FPL income* group.

Discussion

To our knowledge, our study is the first to report that intentions to initiate and complete the HPV vaccine series among parents of unvaccinated adolescents differ considerably among socioeconomically divergent groups in the USA. Nationally, of an estimated 6.2 million unvaccinated US adolescents identified during 2017–2021, the socioeconomically advantaged group constituted the largest fraction (3.8 million) of the total unvaccinated teen population and the proportion of parents lacking intention in this group was the highest (nearly 65%) when compared to the deprived group (41% of parents lack intent equating to 0.5 million adolescents). Notably, the lack of intent to initiate the vaccine series exceeded 40% across all three socioeconomic groups. This is a worrisome finding alluding that lack of intent to initiate the HPV vaccine might linger as a challenge in certain subgroups even if the USA transitions to a single dose HPV vaccine schedule in the future.[26] Additionally, 2.6 million of the total 4.1 million not fully vaccinated adolescents were socioeconomically advantaged; nearly 44% of parents of these adolescents had no intention to fully vaccinate their child. The high parental lack of intent to initiate and complete HPV vaccination, particularly among those from middle or upper-income and educated households, is troubling and highlights the need for targeted interventions to address parental HPV vaccine hesitancy.

The current study further elucidates the nuances between and within race/ethnic groups, highlighting the

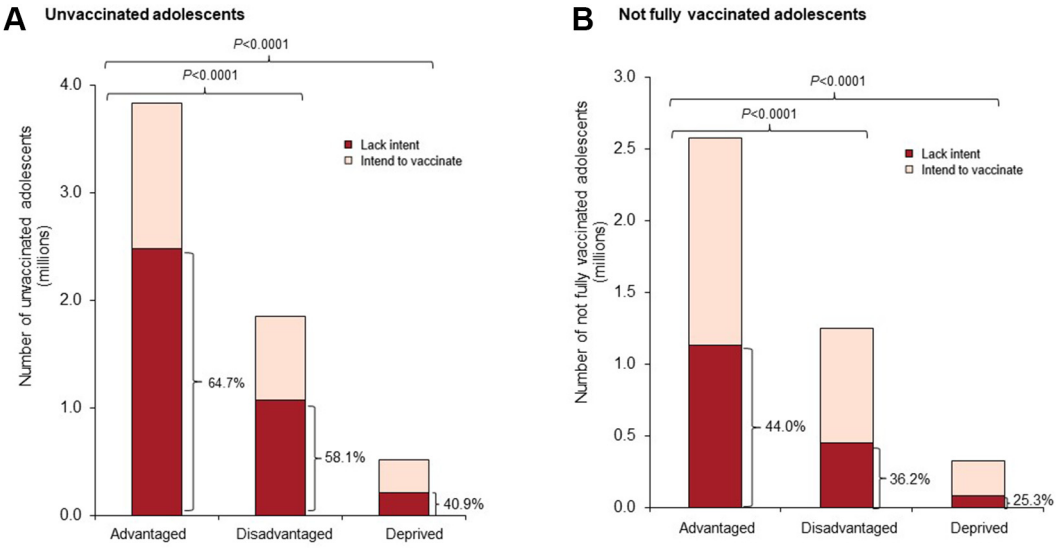

Fig. 2: **Sensitivity analyses for parental lack of intention to initiate and complete the HPV vaccine series across the three socioeconomic groups**. **PANEL A** illustrates population size and parental lack of intent to initiate the HPV vaccine series by advantaged, disadvantaged, and deprived groups. **PANEL B** illustrates population size and parental lack of intent to complete the HPV vaccine series in the advantaged, disadvantaged, and deprived groups. Abbreviations: HPV, Human papillomavirus; NIS, National Immunization Survey. [a]*P* values for survey design-adjusted Wald *F* test for pairwise comparisons.

complex interplay between socioeconomic status, race, and parental HPV vaccine intentions. Although the proportion of parents lacking intent was highest among non-Hispanic Whites from advantaged households, compared to racial and ethnic minorities, no significant difference in odds between advantaged versus deprived groups was observed among non-Hispanic Whites. This finding suggests that lack of intent is pervasive among non-Hispanic White parents regardless of socioeconomic status. In general, qualitative data shows that HPV vaccine acceptance is relatively higher among low-income and minority parents.[27–30] The perceived susceptibility to HPV infection for their child is higher among parents from racial/ethnic minority groups.[28,31] Moreover, the perceived severity of the consequences of HPV infection is also greater among low-income and minority parents.[27] While parents' perceived susceptibility and severity of HPV might be contributing to racial/ethnic differences in HPV vaccine intentions, it remains unclear how socioeconomic status mediates parental HPV vaccine intentions.

The main reasons for parental lack of intention in the advantaged and deprived groups offer some explanation for the observed differences in HPV vaccination intentions by socioeconomic status. In the deprived group, the three most common reasons for no parental intent to initiate the vaccine series were lack of knowledge, vaccine safety concerns, and lack of provider recommendation. In comparison, vaccine 'safety concerns' emerged as the most prominent reason, followed by 'not needed' for the lack of intention in the advantaged group. The overwhelming number of parents in the advantaged group citing 'safety concerns' and 'not needed' despite multiple studies attesting to the safety and effectiveness of HPV vaccine indicates that perceptions of side effects or harms may be exaggerated, and the benefits are likely downplayed (protection against sexually transmitted infection as opposed to cancer prevention) among these parents of unvaccinated adolescents from socioeconomically privileged households.[32–35] However, among those not fully vaccinated, 'already up-to-date' was cited most frequently in both advantaged (58.4%) and deprived (37.1%) groups suggesting that parents may not be aware that multiple doses (2 or 3, based on age at series initiation) are required for their child to be HPV vaccine up-to-date.

The impact of socioeconomic status on individual choices and group interactions has been examined in human psychology research but remains understudied in the context of HPV vaccination.[36–38] Individuals from low socioeconomic status households tend to adopt risk-averse and pro-social behaviors.[39,40] This observation provides some explanation as to why low-income and minority parents might be more receptive to the HPV vaccine.[27–29] Furthermore, when socioeconomic polarization is dominant in society, individuals tend to favor interactions with those who are "like" (in-group interactions) themselves and are averse to out–group interactions. Evidence from social media discourse studies confirms that pro- and anti-vaccine 'echo chambers' are prevalent on social networking sites and the amplification of vaccine-related notions in social echo chambers

Independent variable	Lack of parental intent to initiate the HPV vaccine for unvaccinated adolescents	Lack of parental intent to complete the HPV vaccine for not fully vaccinated adolescents
	Adjusted odds ratio (95% CI)	
Socioeconomic group	*P < 0.0001; S > 13.29*	*P < 0.0001; S > 13.29*
Advantaged	1.92 (1.66–2.21)	1.91 (1.55–2.35)
Disadvantaged	1.73 (1.50–2.00)	1.62 (1.32–2.00)
Deprived	Ref	Ref
Age	*P < 0.0001; S > 13.29*	*P < 0.0001; S > 13.29*
15–17 years	1.40 (1.31–1.48)	2.88 (2.64–3.14)
13–14 years	Ref	Ref
Sex	*P = 0.50; S = 1.00*	*P = 0.001; S = 9.96*
Female	1.02 (0.96–1.09)	1.13 (1.05–1.22)
Male	Ref	Ref
Race/ethnicity	*P < 0.0001; S > 13.29*	*P < 0.0001; S > 13.29*
Non-Hispanic White	1.76 (1.61–1.94)	1.37 (1.21–1.54)
Non-Hispanic Black	1.14 (1.01–1.29)	0.91 (0.79–1.06)
Hispanic	Ref	Ref
Other	1.31 (1.16–1.50)	1.24 (1.06–1.45)
HPV vaccine mandate[b]	*P = 0.77; S = 0.38*	*P = 0.19; S = 2.39*
Yes	1.03 (0.85–1.23)	0.88 (0.73–1.07)
No	Ref	Ref
Housing tenure	*P < 0.0001; S > 13.29*	*P = 0.003; S = 8.38*
Own	1.19 (1.10–1.30)	1.18 (1.06–1.31)
Rent	Ref	Ref
Region	*P = 0.17; S = 2.55*	*P = 0.01; S = 6.64*
Northeast	Ref	Ref
Midwest	1.10 (1.01–1.20)	1.02 (0.93–1.13)
South	1.06 (0.98–1.15)	1.41 (1.04–1.25)
West	1.08 (0.97–1.21)	1.14 (1.00–1.30)
Provider recommendation	*P = 0.01; S = 6.64*	*P = 0.02; S = 5.64*
No	1.08 (1.02–1.16)	1.27 (1.03–1.57)
Yes	Ref	Ref

[a]The logistic regression model was simultaneously adjusted for independent variables. [b]HPV vaccine mandate regions include the District of Columbia, Rhode Island, and Virginia. The state of Hawaii was not included as the mandate was implemented in July 2020.
Abbreviations: HPV, Human papillomavirus.

Table 2: **Multivariable logistic regression models for the associations between socioeconomic status and lack of parental intent to initiate (for unvaccinated) and complete (for not fully vaccinated) the HPV vaccine series.[a]**

is correlated with individuals' vaccine beliefs and opinions.[41–43] These prior studies and our findings are highly relevant and important in the current environment of growing socioeconomic inequalities, rise in vaccine safety concerns, and the COVID-19 pandemic fueling misinformation regarding vaccines in the US.[35,44] If the erosion of public confidence in vaccines persists, the negative vaccination sentiment could plateau HPV vaccination rates and threaten the progress the USA has achieved so far.[45,46] Notably, the 2023 CDC report suggests that HPV vaccination rates did not improve in recent birth cohorts, specifically, rates declined among those living at or above the poverty level, non-Hispanic Whites, those living in metro areas, and among those covered by private insurance.[1]

Limitations of our study should be carefully considered when interpreting the study findings. The goal of the current study was to understand parental vaccination intentions; therefore, we used the full sample (parent-reported data) and not the provider-verified subsample of NIS-Teen. The main findings in this study compared the advantaged versus deprived quantifying lack of parental intent as a binary outcome (Yes/No), which provides an easy-to-interpret presentation of our findings. Data for all three socioeconomic groups, intention as an ordinal outcome, and deconstructed group odds are available to the readers in the supplement. Participants in the NIS-Teen were asked to report only the main reason for their lack of intent to vaccinate; parents of some adolescents might have had more than one reason for the lack of intent. However, capturing the primary reason allowed us to identify the most prominent concern of parents for their lack of intent to vaccinate their child with the HPV vaccine. The terms advantaged, disadvantaged, and deprived are relative and reflect a lack of equivalent education and income

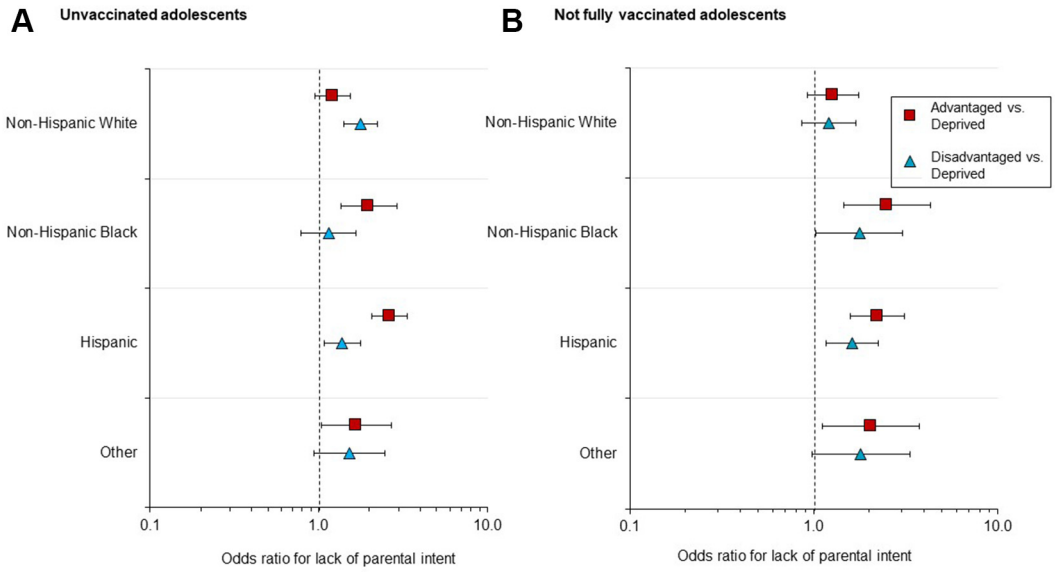

***Fig.* 3: Odds ratios for parental lack of intent in the advantaged versus deprived group and disadvantaged versus deprived group stratified by race/ethnicity.**[a] Figure **PANEL A** presents adjusted odds for parental lack of intent to initiate the HPV vaccine series for the advantaged versus deprived group and disadvantaged versus deprived group. **PANEL B** presents adjusted odds for parental lack of intent to complete the HPV vaccine series for the advantaged versus deprived group and disadvantaged versus deprived group. Odds ratios are stratified by race/ethnicity and were determined using self-reported race/ethnicity information. Abbreviations: HPV, human papillomavirus; NIS, National Immunization Survey. [a]Adjusted odds ratios were derived from multivariable logistic regression models adjusted for age group, sex, race/ethnicity of the adolescent, housing tenure, HPV vaccination mandate policy in the state of adolescents' residence, and region. Models were adjusted for the complex survey design and weighted using the NIS-Teen full sample survey weights. The horizontal axis is the log scale. Error bars represent 95% confidence intervals. S-value for unvaccinated groups are as follows: non-Hispanic Whites (8.3), non-Hispanic Blacks (>13.29), Hispanics (>13.29), and 'Other' (3.4). S-value for unvaccinated groups are as follows: non-Hispanic Whites (1.8), non-Hispanic Blacks (12.3), Hispanics (>13.29), and 'Other' (3.9).

between the groups. Finally, the cross-sectional nature of the data and unmeasured confounding precludes making causal or temporal inferences. While the limitations listed above are inherent to surveys, the nationally representative sample and information on parental HPV vaccination intentions and reasons for lack of intent provide unique data that are generalizable to US parents. These data could inform 1) tailoring and targeting interventions for addressing parental HPV vaccine reluctance among sociodemographic subgroups and, 2) the development of new interventions to eliminate parental barriers to vaccination.

In conclusion, among the unvaccinated and not fully vaccinated US adolescents, factors associated with parental HPV vaccination intentions, when viewed through the lens of socioeconomic status, reveal a prominent difference between the advantaged and the deprived groups. Given that a significant proportion of the HPV unvaccinated and not fully vaccinated adolescent population were from educated and above poverty level income households, implementing strategies that will address barriers to both initiation and completion in this group is necessary. The considerable number of parents lacking the intent to initiate the HPV vaccine series for their unvaccinated adolescents highlights the need for improving vaccine confidence. Interventions that provide facts on vaccine safety and effectiveness and debunk HPV vaccine myths at an individual- and/or community-level, along with strong recommendations by healthcare providers, will be necessary to avoid stagnation of HPV vaccine rates and to continue making progress towards achieving the 80% national goal.

Contributors

KS, YZ, and AAD were responsible for the conceptualization of the manuscript, data curation, methodology, software, formal analysis, visualization, writing the original draft, and reviewing and editing the manuscript. HD and AG were responsible for the conceptualization of the manuscript, verification of the data, methodology, reviewing, and editing of the manuscript. EMG, MEF, and JRR were responsible for conceptualization, reviewing, and editing the manuscript. ARG, NCB, JRM, and KRS were responsible for methodology, reviewing, and editing the manuscript. KS made the final decision to submit the manuscript.

Data sharing statement

The National Immunization Survey database and analytical guidelines are publicly available through the US Centers for Disease Control and Prevention (https://www.cdc.gov/vaccines/imz-managers/nis/datasets-teen.html).

Declaration of interests
Drs. Sonawane and Deshmukh have provided consultancy to Value Analytics Labs on unrelated projects. Dr. Giuliano received honoraria, and grant funding, and served as a member of the scientific advisory board on unrelated projects for Merck Sharp and Dohme. All other authors declare no competing interests.

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Appendix A. Supplementary data
Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100694.

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