RESEARCH ARTICLE / ARAŞTIRMA

DOI: 10.4274/mjima.galenos.2026.26870
Mediterr J Infect Microb Antimicrob 2026;15: 2026.26870
Erişim: http://dx.doi.org/10.4274/mjima.galenos. 2026.26870

Seroprevalence of HPV Infection in Healthcare Workers with Molecular Confirmation of High-Risk HPV

Sağlık Çalışanlarında HPV Enfeksiyonunun Seroprevalansı ve Yüksek Riskli HPV'nin Moleküler Doğrulaması

Ahmed Qasim Risan, Ahmed Hasan Mohammed

University of Thi-Qar College of Science, Department of Pathological Analysis, Nasiriyah, Iraq

Abstract

Introduction: High-risk human papillomavirus (HR-HPV) genotypes, particularly HPV-16 and HPV-18, are the primary etiologic agents of various carcinomas. Healthcare workers face a significant risk of non-sexual occupational exposure to oncogenic HPV through the inhalation of surgical smoke and aerosols generated during medical procedures. This study aimed to determine the seroprevalence of anti-HPV IgG and IgM antibodies and detect circulating HR-HPV deoxyribonucleic acid (DNA) among healthcare workers to assess potential occupational cancer risks.

Materials and Methods: A cross-sectional study evaluated 170 healthcare workers from general hospitals in Al-Shatra General Hospital and Al-Haboubi Teaching Hospital in Dhi Qar Governorate, Iraq. Serum concentrations of anti-HPV IgG and IgM were quantified using an enzyme-linked immunosorbent assay. To investigate transient HPV DNAemia indicative of intense occupational exposure, conventional polymerase chain reaction (PCR) was performed on a subset of 100 seropositive samples (IgM >0.25 nmol/L) to detect circulating cell-free DNA of HPV-16 and HPV-18.

Results: A remarkably high seroprevalence was observed, with 95.9% and 90.0% of participants testing positive for anti-HPV IgG and IgM, respectively. Despite this, molecular analysis revealed a low rate of active viral shedding; HPV-16 DNA was detected in only 7.0% of the subset, whereas HPV-18 was not detected. Participants who tested positive for HPV-16 by PCR exhibited significantly higher anti-HPV IgM levels than PCR-negative individuals ($p < 0.0001$).

Conclusion: The substantial discrepancy between the widespread serological prevalence and the low rate of molecular detection may indicate a potential association between occupational exposure to HR-HPV and transient viremia. This unrecognized exposure underscores a potential latent oncogenic hazard in clinical settings. These findings highlight the urgent need for stringent personal protective measures, improved ventilation during procedures, and targeted prophylactic vaccination strategies for healthcare personnel to mitigate the risk of HPV-driven cancers.

Keywords: Human papillomavirus 16, human papillomavirus 18, ELISA, PCR

Öz

Giriş: Yüksek riskli insan papillomavirüsü (HR-HPV) genotipleri, özellikle HPV-16 ve HPV-18, çeşitli karsinomların birincil etiyolojik ajanlarıdır. Sağlık çalışanları, cerrahi duman ve tıbbi işlemler sırasında oluşan aerosollerin solunması yoluyla onkojenik HPV›ye cinsel olmayan mesleki maruz kalma riskiyle karşı karşıyadır. Bu çalışma, potansiyel mesleki kanser risklerini değerlendirmek amacıyla sağlık çalışanları arasında anti-HPV IgG ve IgM antikorlarının seroprevalansını belirlemeyi ve dolaşımdaki HR-HPV DNA›sını tespit etmeyi amaçlamıştır.

Gereç ve Yöntem: Kesitsel bir çalışmada, Al-Shatra Genel Hastanesi ve Al-Haboubi Eğitim Hastanesi bölgesindeki genel hastanelerden 170 sağlık çalışanı değerlendirilmiştir. Anti-HPV IgG ve IgM'nin serum konsantrasyonları, enzim bağlantılı immünosorbent testi kullanılarak ölçülmüştür. Yoğun mesleki maruziyete işaret eden geçici HPV DNAemisini araştırmak için, dolaşımdaki hücre dışı HPV-16 ve HPV-18 DNA'sını tespit etmek amacıyla 100 seropozitif örnekten oluşan bir alt kümede (IgM > 0,25 nmol/L) geleneksel polimeraz zincir reaksiyonu (PCR) uygulandı.

Cite this article as: Risan AQ, Mohammed AH. Seroprevalence of HPV infection in healthcare workers with molecular confirmation of high-risk HPV. Mediterr J Infect Microb Antimicrob. 2026;15:189-196

Address for Correspondence/Yazışma Adresi: Ahmed Qasim Risan, University of Thi-Qar College of Science, Department of Pathological Analysis, Nasiriyah, Iraq
E-mail: ahmed.qasim@utq.edu.iq **ORCID ID:** orcid.org/0009-0006-1297-0532
Received/Geliş Tarihi: 01.05.2026 **Accepted/Kabul Tarihi:** 15.06.2026

Published: 20.08.2026

Bulgular: Katılımcıların %95,9'unda ve %90,0'ında sırasıyla anti-HPV IgG ve IgM için pozitif test sonucu elde edilmesiyle oldukça yüksek bir seroprevalans gözlemlendi. Buna rağmen, moleküler analiz aktif viral yayılım oranının düşük olduğunu ortaya koydu; HPV-16 DNA'sı alt kümenin sadece %7,0'ında tespit edilirken, HPV-18 tespit edilmedi. PCR ile HPV-16 için pozitif test sonucu veren katılımcılar, PCR negatif bireylere göre anlamlı derecede daha yüksek anti-HPV IgM seviyeleri sergiledi ($P < 0,0001$).

Sonuç: Yaygın serolojik prevalans ile düşük moleküler tespit oranı arasındaki önemli tutarsızlık, mesleki olarak yüksek riskli HPV'ye maruz kalma ile geçici viremi arasında potansiyel bir ilişkiye işaret edebilir. Bu fark edilmeyen maruziyet, klinik ortamlarda potansiyel bir latent onkojenik tehlikeyi vurgulamaktadır. Bu bulgular, HPV kaynaklı kanser riskini azaltmak için sağlık personeline yönelik sıkı kişisel koruyucu önlemlere, işlemler sırasında iyileştirilmiş havalandırmaya ve hedefli profilaktik aşılama stratejilerine acil ihtiyaç olduğunu vurgulamaktadır.

Anahtar Kelimeler: İnsan Papillomavirüsü 16; İnsan Papillomavirüsü 18; ELISA; PCR

Introduction

Millions of new HPV infections occur annually worldwide, highlighting the remarkable transmissibility and widespread distribution of the virus. It has been estimated that approximately 6.2 million people acquire a new HPV infection each year[1]. Human papillomavirus (HPV) is one of the most prevalent sexually transmitted infections worldwide and imposes a substantial public health burden[2]. Taxonomically classified within the Papillomaviridae family, HPV is a small, non-enveloped, double-stranded deoxyribonucleic acid (DNA) virus with an approximate diameter of 55 nm[3]. The viral genome encodes eight proteins, among which the E6 and E7 oncoproteins are of paramount clinical significance. These oncoproteins play a critical role in cellular transformation and oncogenesis by disrupting essential cell cycle regulatory mechanisms. Specifically, E6 facilitates the degradation of the tumor suppressor protein p53, thereby enabling evasion of apoptosis, whereas E7 binds to and inactivates the retinoblastoma protein (pRb), leading to uncontrolled cellular proliferation[4]. The intricate molecular interplay between these viral oncoproteins and host cellular machinery underpins the pathogenesis of HPV-induced malignancies.

To date, more than 200 distinct HPV genotypes have been identified and characterized. Based on their oncogenic potential and epidemiological association with cancer, approximately 13-15 genotypes are classified as high-risk HPV (HR-HPV)[5]. These high-risk variants, including HPV-16, HPV-18, HPV-31, HPV-33, and HPV-35, exhibit a strong oncogenic potential and are closely associated with the development of various anogenital and oropharyngeal carcinomas. Conversely, low-risk genotypes are predominantly associated with benign verruciform lesions[6]. Persistent infection with HR-HPV is the primary causative factor in the development of precancerous and malignant lesions of the cervix, vulva, vagina, penis, and anus. Globally, HPV-16 and HPV-18 are the most prevalent oncogenic genotypes, collectively accounting for more than 70% of all invasive cervical cancer cases[7,8]. The substantial oncogenic potential of these genotypes necessitates rigorous surveillance and molecular profiling in susceptible populations. The transmission dynamics of HPV are predominantly characterized by direct skin-to-skin sexual contact. However, accumulating epidemiological and clinical evidence indicates that non-sexual routes of transmission also contribute to viral spread. These alternative routes include vertical transmission from mother to infant during childbirth, direct contact with contaminated fomites, and horizontal transmission among children through non-sexual physical contact with infected cutaneous lesions[9]. Furthermore, the persistence of the virus in environmental reservoirs and its resistance to desiccation highlight the potential for fomite-mediated transmission in specific settings. In the context of occupational health, healthcare workers are increasingly recognized as a population at risk of non-sexual HPV exposure. Medical personnel, particularly those specializing in gynecology, dermatology, otolaryngology, and urology, frequently encounter HPV-infected tissues. A significant occupational hazard arises from the generation of surgical smoke and aerosols during electrosurgical ablation, laser vaporization, or excision of HPV-associated lesions[10]. Viral DNA and intact virions have been detected in surgical plumes, posing a risk of inhalation-mediated inoculation of the nasal and oropharyngeal mucosa. Consequently, the occurrence of HPV-associated oropharyngeal disease among healthcare providers has prompted investigations into occupational transmission risks. Although prophylactic vaccination, the consistent use of personal protective equipment (PPE), and effective local exhaust ventilation are recommended to mitigate these hazards, comprehensive data on the actual serological and molecular prevalence of HPV among healthcare workers remain limited[11].

Given the potential for unrecognized occupational exposure and the subsequent risk of acquiring high-risk oncogenic strains, it is imperative to evaluate the immunological and virological status of healthcare personnel. Although HPV is strictly an epitheliotropic virus, emerging evidence suggests that circulating cell-free HPV DNA (HPV DNAemia) can be detected in the bloodstream, primarily in patients with invasive HPV-associated carcinomas. However, it remains unknown whether intense occupational exposure, such as the chronic inhalation

of intact virions or viral DNA fragments from surgical smoke, could lead to the transient translocation of these fragments into the systemic circulation. Therefore, exploring the presence of circulating HPV DNA in serum may serve as a novel biomarker of substantial systemic occupational exposure rather than an indicator of localized active infection.

This study aimed to determine the seroprevalence of anti-HPV IgG and IgM antibodies among healthcare workers in Al-Shatra General Hospital and Al-Haboubi Teaching Hospital in Dhi Qar Governorate, Iraq and to investigate the presence of circulating high-risk HPV DNA fragments (HPV-16 and HPV-18) in serum using conventional polymerase chain reaction (PCR) assays as an indicator of transient DNAemia.

Materials and Methods

Study Design and Participants

A descriptive cross-sectional study was conducted between November 2025 and December 2025 across multiple general hospitals in Al-Shatra General Hospital and Al-Haboubi Teaching Hospital in Dhi Qar Governorate, Iraq. The study cohort comprised 170 healthcare workers, including physicians, nurses, and allied healthcare staff from various clinical departments. Specifically, the cohort included surgical staff and gynecologists who were frequently exposed to surgical plumes, laboratory technologists handling clinical specimens, and ward nurses engaged in routine patient care. In accordance with the principles of the Declaration of Helsinki, the research protocol was reviewed and approved by the University of University of Thi-Qar Institutional Scientific Research Ethics Committee (approval no: B-2025-41630, date: 03.11.2025). Written informed consent was obtained from all participants before enrollment and subsequent data collection.

Inclusion and Exclusion Criteria

The target population consisted of male and female healthcare workers aged 20-59 years. The inclusion criteria required participants to have no prior history of prophylactic HPV vaccination, no clinical symptoms indicative of sexually transmitted infections (e.g., genital warts), and a willingness to provide informed consent. Individuals with chronic systemic diseases, pregnant women, and older adults (≥60 years) were excluded from the study to minimize confounding immunological variables. Vaccination status was determined by self-report; although this approach may introduce slight recall bias, the risk is considered minimal because the HPV vaccine is not currently part of the routine national immunization program in the region.

Sample Collection and Preparation

Peripheral venous blood samples (5 mL) were collected from each participant using standard aseptic venipuncture techniques. Whole blood was allowed to clot at room temperature for 30 min, followed by centrifugation at 3,000 × *g* for 10 min. The separated serum was carefully aliquoted into sterile microcentrifuge tubes and stored at -20 °C for a maximum of four weeks before subsequent serological and molecular analyses to preserve nucleic acid integrity.

Serological Assay Procedure

The quantitative determination of anti-HPV IgG and IgM antibodies in serum samples was performed using a commercial sandwich enzyme-linked immunosorbent assay (ELISA) kit (Sunlong Biotech, China) according to the manufacturer's instructions. Optical density was measured immediately at 450 nm using a microplate reader. Samples with IgG levels >1 nmol/L and IgM levels >0.25 nmol/L were classified as seropositive. These seropositivity thresholds were established strictly according to the manufacturer's instructions without additional modifications by the local laboratory.

Exploratory Detection of Circulating Cell-Free HPV DNA

To investigate the possibility of transient HPV DNAemia resulting from occupational exposure, viral nucleic acids (cell-free DNA) were extracted from 200 µL of serum using the Viral Nucleic Acid Extraction Kit III (Geneaid, Taiwan). For this molecular analysis, a subset of 100 seropositive samples was used. This subset was purposively selected based on the highest anti-HPV IgM concentrations to maximize the probability of detecting transient DNAemia. This kit is specifically optimized for cell-free samples. This system employs a glass fiber spin column optimized for cell-free samples, yielding purified viral DNA within 60 min. The detection of HPV-16 and HPV-18 was performed using conventional PCR with specific primers designed by Macrogen (Seoul, South Korea). The primer sequences were as follows: HPV-16 (5'-CACAGTTATGCACAGAGCTGC-3' and 5'-CATATATTCATGCAATGTAGGTGTA-3') and HPV-18 (5'-CACTTCACTGCAAGACATAGA-3' and 5'-GTTGTGAAATCGTCGTTTTTCA-3')[12]. PCR amplification was conducted in a total reaction volume of 25 µL, comprising 10 µL of master mix, 1 µL each of the forward and reverse primers (10 pmol/µL), 5 µL of the extracted DNA template, and 8 µL of nuclease-free water. The thermal cycling conditions included an initial denaturation at 94 °C for 4 min, followed by 35 cycles of denaturation at 94 °C for 30 s, annealing at 56 °C for 30 s, and extension at 72 °C for 45 s. A final extension step was performed at 72 °C for 4 min. The amplified products were resolved by electrophoresis on a 1.8% agarose gel stained with 0.3 mg/mL

safe dye at 80 V for 30 min. Visualization under ultraviolet light identified positive samples based on the presence of a 457-bp amplicon for HPV-16 and a 322-bp amplicon for HPV-18.

Statistical Analysis

Due to the exploratory nature of this study and the specific occupational demographic targeted, a non-probability convenience sampling method was used. The final sample size of 170 healthcare workers was determined based on the availability of eligible participants who met the predefined inclusion and exclusion criteria and provided informed consent during the two-month study period.

Data management and statistical analyses were performed using (insert software, e.g., IBM SPSS Statistics version 26.0). Categorical variables were presented as frequencies and percentages, whereas continuous variables were expressed as means ± standard deviation (SD) or medians (ranges), depending on the normality of the data distribution, which was assessed using the Shapiro-Wilk test and confirmed to be non-normal. Group comparisons were performed using the non-parametric Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. A two-sided p-value < 0.05 was considered statistically significant. Due to the limited number of PCR-positive cases (n = 7), advanced predictive modeling was deferred to prevent statistical overfitting and ensure the robustness of the descriptive findings.

Results

The study cohort consisted of 170 healthcare workers. The age distribution showed that the majority of participants were younger than 30 years (n = 95, 55.9%), followed by those aged 30-39 years (n = 61, 35.9%) and those aged ≥40 years (n = 14, 8.2%). The sex distribution was nearly equal, with 86 males (50.6%) and 84 females (49.4%). Regarding marital status, 121 participants (71.2%) were married, 44 (25.9%) were single, and 5 (2.9%) were divorced (Table 1).

Serological evaluation demonstrated a remarkably high prevalence of HPV-specific antibodies among healthcare workers. Specifically, 95.9% (n = 163) of the participants tested positive for anti-HPV IgG antibodies. Most seropositive individuals (78.2%) exhibited moderate IgG concentrations ranging from 1 to 4 nmol/L. Only a small proportion (6.5%) demonstrated high IgG titers exceeding 12 nmol/L. The overall median IgG concentration across the cohort was 2.04 nmol/L (range, 1.77-2.15 nmol/L). Similarly, a high seroprevalence of anti-HPV IgM antibodies was observed, with 90.0% (n = 153) of the participants testing positive. Among the seropositive participants, 77.1% had IgM concentrations between 0.25 and 1 nmol/L, whereas 2.9% displayed elevated levels greater than 3 nmol/L. The median IgM concentration was 0.39 nmol/L (range, 0.35-0.44 nmol/L). Statistical analysis revealed highly significant differences in the distribution of both IgG and IgM concentrations across the study population ($p < 0.001$) (Table 2).

To validate the presence of active high-risk HPV infections, conventional PCR targeting HPV-16 and HPV-18 was performed on a subset of 100 samples exhibiting moderate-to-high anti-HPV IgM concentrations (>0.25 nmol/L). Despite the high seroprevalence, molecular analysis indicated a low frequency of active viral shedding. Of the 100 samples tested, 93 (93.0%) were negative for both genotypes. Only seven samples (7.0%) tested positive for HPV-16 DNA, whereas all samples were negative for HPV-18.

A comparative analysis of IgM concentrations between PCR-positive and PCR-negative individuals revealed significant differences. Individuals who tested positive for HPV-16 by PCR exhibited significantly higher IgM levels (mean ± SD, 2.89 ± 0.19 nmol/L; range, 2.55-3.00 nmol/L) than PCR-negative individuals (mean ± SD, 0.73 ± 0.59 nmol/L; range, 0.338-2.492 nmol/L). A non-parametric Mann-Whitney U test confirmed that the elevation in anti-HPV IgM concentrations in the PCR-positive group was highly statistically significant compared with that in the PCR-negative group ($U = 651.0$, $p < 0.0001$) (Table 3). Given the limited number of PCR-positive cases (n =

Table 1. Demographic characteristics of the study population

	Occupation	Employee (n = 170)
Age groups	<30 years	95
	30–39 years	61
	≥40 years	14
Sex	Female	84
	Male	86
Marital status	Single Married Divorced	44 121 5
Total	170	

7), further predictive modeling (such as logistic regression or receiver operating characteristic curve analysis) was deferred to avoid statistical overfitting and maintain the robustness of the descriptive findings.

Discussion

Particular attention was given to the healthcare workers group to assess the prevalence of HPV exposure among individuals working in occupational settings. The present study evaluated the immunological response, represented by anti-HPV IgG and IgM antibodies, and confirmed active infection with high-risk genotypes through the detection of viral DNA in blood samples. The findings reveal a complex interplay between high seroprevalence and low molecular detection rates, underscoring the unique occupational risks faced by healthcare workers.

A central finding of this study is the striking discrepancy between serological and molecular detection rates. Serological analysis revealed an exceptionally high prevalence of HPV-specific antibodies, with 90.0% (153/170) testing positive for IgM and 95.9% (163/170) testing positive for IgG. This indicates widespread recent or ongoing exposure (IgM), as well as previous exposure and a long-term immune response (IgG). Despite this high seroprevalence, molecular detection using conventional PCR revealed a comparatively low frequency of active viral shedding, with only 7.0% of participants testing positive for HPV-16 and no cases detected for HPV-18.

This discrepancy between the serological and molecular findings reflects the natural history of HPV infection, in which viral clearance often occurs while specific antibodies remain detectable for prolonged periods[13]. Furthermore, recent studies have corroborated this phenomenon in different populations. For instance, Irakli et al.[14] investigated asymptomatic individuals in Georgia and reported a similar diagnostic divergence in the opposite direction, highlighting that serological and molecular assays measure fundamentally different aspects of HPV infection: historical immunological exposure vs. active viral replication. The serological assay used in the present study detects antibodies against a broad range of antigenically diverse HPV genotypes, whereas the molecular analysis specifically targeted only two high-risk genotypes (HPV-16 and HPV-18).

The high seroprevalence observed in this cohort raises significant concerns regarding occupational exposure among healthcare workers. Although sexual contact remains the primary route of HPV transmission, non-sexual occupational transmission is increasingly recognized as an important public health concern. Recent systematic reviews have highlighted that healthcare providers, particularly those treating HPV-associated lesions, face substantial occupational risks because of exposure to surgical smoke and aerosols generated during electrosurgical ablation, laser vaporization, or excision procedures[11].

Table 2. Serological detection and distribution of healthcare workers according to anti-HPV IgG and IgM concentrations.

Serological markers	Category (nmol/L)	Frequency	Percentage (%)	Median (range)	p-value
ELISA IgG	<1	6	3.50%	2.04 (1.77-2.15)	<0.001
	1-4	133	78.20%		
	4-8	9	5.30%		
	8-12	11	6.50%		
	>12	11	6.50%		
ELISA IgM	<0.25 0.25-1	17 131	10.00 77.10	0.39 (0.35-0.44)	<0.001
	1-2	9	5.30		
Total	2-3 >3	8 5 170	4.70 2.90		

ELISA, enzyme-linked immunosorbent assay; IgM, immunoglobulin M.

Table 3. Descriptive statistics of anti-HPV IgM distribution with PCR results.

PCR results	n	Anti-HPV IgM mean	SD	Median	Min.	Max.
Negative	93	0.73	0.59	0.48	0.338	2.492
Positive	7	2.89	0.19	3.00	2.55	3.00

The results of the Mann-Whitney U test indicated a highly significant difference in IgM concentrations between PCR-positive and PCR-negative participants ($U=651.0$, $p<0.0001$).

anti-HPV, anti–human papillomavirus; IgM, immunoglobulin M; PCR, polymerase chain reaction; SD, standard deviation.

Fox-Lewis et al.[15] demonstrated that HPV DNA is frequently detected in surgical smoke and on PPE, as well as in the oral mucosa and nasal cavities of exposed healthcare workers. Furthermore, procedures such as endotracheal aspiration, intubation, and bronchoscopy have been identified as aerosol-generating procedures that may facilitate viral transmission[11]. Despite these established risks, awareness and preventive practices remain suboptimal. A study by Wu et al. [10] evaluating the knowledge, attitudes, and practices of healthcare providers revealed that fewer than 50% possessed adequate knowledge regarding occupational HPV exposure, and only half had been vaccinated against HPV despite strong recommendations from professional societies. The exceptionally high seroprevalence observed in our study cohort (95.9% for IgG and 90.0% for IgM) strongly suggests continuous environmental exposure within the hospital setting. In occupational environments, the chronic inhalation of aerosolized viral particles may serve as a persistent antigenic stimulus, potentially maintaining elevated IgM levels for longer than those observed in typical mucosal infections. However, this high positivity rate must be interpreted with an important methodological caveat. The commercial ELISA used in this study detects generic anti-HPV antibodies and may not strictly differentiate between mucosal high-risk genotypes and common cutaneous low-risk HPV types (e.g., those causing common skin warts). Consequently, immunological cross-reactivity with other highly prevalent Papillomaviridae strains cannot be entirely ruled out, which may have contributed to the elevated seropositivity rates. Importantly, because this study did not include a non-healthcare control group, community-acquired transmission cannot be definitively excluded and remains a significant confounding factor when interpreting the high seroprevalence. Despite this limitation, the detection of such robust immune responses underscores the need for strict adherence to PPE protocols and the implementation of effective local exhaust ventilation systems.

A demographic analysis of our cohort revealed significant associations between age, sex, marital status, and HPV seroprevalence. Most participants (55.9%) were younger than 30 years, and a statistically significant association was observed between younger age groups and a higher prevalence of HPV antibodies ($p < 0.001$). This finding is consistent with the results reported by Adoga et al.[16], who observed a higher prevalence of HPV antibodies among individuals younger than 30 years than among older cohorts. Similarly, Mujuni et al.[17] reported a steady decline in HPV seroprevalence with increasing age, from 46% among individuals aged 15-25 years to 16.3% among those aged 36-45 years. This pattern is largely attributed to higher levels of sexual activity among younger individuals and the immune system's ability to clear approximately 90% of HPV infections within 2 years, resulting in partial protective immunity that may reduce the risk of reinfection in older individuals[18].

It is important to note that this trend among younger cohorts may primarily reflect behavioral and lifestyle factors rather than being exclusively associated with occupational hazards. Regarding sex distribution, a statistically significant difference was observed ($P = 0.008$) between male (50.6%) and female (49.4%) healthcare workers. The slight predominance of men in the present study may reflect the occupational structure of the study population. These findings are partially consistent with those of a study conducted in China by Xiang et al.[19], which reported nearly identical prevalence rates among women (50.64%) and men (50.79%).[18] However, they contrast with the findings of I. Rezaee Azhar et al.[20] in Iran, where the prevalence was considerably higher among women (87%) than among men (13%). Marital status also appeared to influence exposure, as 71.2% of the healthcare workers in this study were married. Given that HPV is transmitted predominantly through sexual contact, marriage may cumulatively increase the likelihood of HPV exposure over time[21].

The detection of HPV-16 in 7.0% of the molecularly tested subset is clinically significant because of its substantial oncogenic potential and strong association with multiple anogenital and oropharyngeal malignancies[22]. The prevalence of HPV-16 observed in the present study is comparable to that reported by Bakir et al.[23], who found a prevalence of 8.0%. However, it is markedly lower than the 33.3% prevalence reported among women in Saudi Arabia by El-Daly et al.[24], suggesting substantial geographic and epidemiological variation in genotype distribution.

Notably, no cases of HPV-18 were detected in the present study. This absence may be attributed to the limited sample size or regional differences in genotype distribution. This finding is consistent with recent epidemiological data from Thailand (0.62% prevalence)[18] and the Philippines (0.92% prevalence) [25], which indicate a very low prevalence of HPV-18 compared with HPV-16. This observation is generally consistent with the regional epidemiological profile, in which HPV-16 has historically been far more prevalent than HPV-18 in the general population.

Study Limitations

A notable limitation of this study is the scarcity of published literature addressing the serological prevalence of HPV specifically among healthcare workers in the Middle East, making direct regional comparisons challenging. Additionally, the cross-sectional design precludes the establishment of causal relationships between specific occupational tasks and HPV acquisition. Furthermore, the broad-spectrum ELISA kit used in this study may have detected cross-reactive antibodies

against benign, non-oncogenic cutaneous HPV types, limiting our ability to attribute the serological findings exclusively to high-risk strains, because cross-reactivity with ubiquitous, non-oncogenic cutaneous HPV variants is highly probable. Future longitudinal studies with larger sample sizes, detailed occupational exposure histories (e.g., hours spent in operating rooms and specific procedures performed), and comprehensive genotyping of both high-risk and low-risk HPV strains are warranted. Moreover, the extraction of cell-free viral DNA was limited to a volume of 200 µL of serum; given the typically low abundance of circulating cell-free DNA, this relatively small volume may have resulted in false-negative findings, thereby underestimating the true prevalence of DNAemia. Additionally, the use of conventional PCR, which inherently has lower sensitivity and a higher limit of detection than quantitative real-timePCR, may have resulted in false-negative results in individuals with very low-copy transient DNAemia.

Conclusion

The findings of this study highlight a widespread history of prior and ongoing HPV exposure among healthcare workers in Al-Shatra General Hospital and Al-Haboubi Teaching Hospital in Dhi Qar Governorate, Iraq, characterized by high seroprevalence but a low rate of active molecular infection. The elevated risk profile, compounded by occupational hazards such as exposure to surgical smoke, underscores an urgent public health concern. It is crucial to enhance routine molecular and serological screening, strengthen occupational health education, and consider targeted prophylactic vaccination strategies for healthcare personnel in accordance with local health guidelines to mitigate the risk of HPV-driven cancers.

Ethics

Ethics Committee Approval: Approved by the University of University of Thi-Qar Institutional Scientific Research Ethics Committee (approval no: B-2025-41630, date: 03.11.2025).

Informed Consent: Written informed consent was obtained from all participants before enrollment and subsequent data collection.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.Q.R., A.H.M., Concept: A.Q.R., A.H.M., Design: A.Q.R., A.H.M., Data Collection or Processing: A.Q.R., A.H.M., Analysis or Interpretation: A.Q.R., A.H.M., Literature Search: A.Q.R., A.H.M., Writing: A.Q.R., A.H.M.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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