

Estimating seroprevalence of herpes simplex virus type 1 among different Middle East and North African male populations residing in Qatar

Gheyath K. Nasrallah PhD^{1,2}  | Soha R. Dargham MPH³ |
Layla I. Mohammed BSc² | Laith J. Abu-Raddad PhD^{3,4} 

¹Department of Biomedical Science, College of Health Sciences, Qatar University, Doha, Qatar

²BioMedical Research Center, Qatar University, Doha, Qatar

³Infectious Disease Epidemiology Group, Weill Cornell Medicine-Qatar, Cornell University, Qatar Foundation—Education City, Doha, Qatar

⁴Department of Healthcare Policy and Research, Weill Cornell Medicine, Cornell University, New York

Correspondence

Laith J. Abu-Raddad, PhD, Infectious Disease Epidemiology Group Weill Cornell Medicine—Qatar Qatar Foundation—Education City P.O. Box 24144 Doha, Qatar.
Email: lja2002@qatar-med.cornell.edu

Funding information

Qatar National Research Fund, Grant number: UREP 18-001-3-001; Qatar National Research Fund, Grant number: NPRP 9-040-3-008; Qatar University, Grant number: QUST-CHS-SPR-15/16-7; Biomedical Research Program at Weill Cornell Medicine-Qatar

HSV-1 epidemiology in the Middle East and North Africa (MENA) remains poorly understood. Our study aimed to measure HSV-1 antibody prevalence (seroprevalence) and its age-distribution among select MENA populations residing in Qatar. Sera were collected from male blood donors attending Hamad Medical Corporation 2013-2015. A total of 2,077 sera were tested for anti-HSV-1 antibodies using HerpeSelect[®] 1 ELISA IgG kits (Focus Diagnostics, Cypress, CA). Robust Poisson regression was conducted to estimate adjusted infection prevalence ratios. Country-specific HSV-1 seroprevalence was estimated for 10 national populations: 97.5% among Egyptians, 92.6% among Yemenis, 90.7% among Sudanese, 88.5% among Syrians, 86.5% among Jordanians, 82.3% among Qataris, 81.4% among Iranians, 81.4% among Lebanese, 80.5% among Palestinians, and 77.0% among Pakistanis. Age-specific HSV-1 seroprevalence was estimated for Egypt, the Fertile Crescent (Iraq, Jordan, Lebanon, Palestine, and Syria), and Qatar. Seroprevalence increased with age among Fertile Crescent and Qatari nationals. Seroprevalence increased from 70.0% among those aged ≤ 24 years up to 98.0% among those aged ≥ 55 years among Fertile Crescent nationals. Seroprevalence was consistently above 90% for all ages among Egyptians. HSV-1 seroprevalence is high in MENA, though with some variation across countries. The seroprevalence appears to have declined among current young age cohorts compared to its levels a few decades ago.

KEYWORDS

herpes, herpes simplex virus type 1, Middle East and North Africa, prevalence, sexually transmitted infection

1 | INTRODUCTION

Herpes simplex virus type 1 (HSV-1) infection is endemic globally and is the primary cause of orolabial herpes.¹⁻⁴ HSV-1 is highly infectious,

with most infections occurring during childhood.^{1,5} Following initial acquisition, the virus introduces latency in nerve cell clusters causing an infection that persists for life.^{3,6} HSV-1 is commonly transmitted by non-sexual contact (primarily through oral secretions), with most

Disclose funding received for this work: Others.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2017 The Authors. *Journal of Medical Virology* Published by Wiley Periodicals, Inc.

infections showing no apparent symptoms.^{3,7,8} When symptomatic, infection is often characterized by oral or facial lesions, that is at the initial portal of entry.^{6,7} HSV-1 infection is associated with oral, cutaneous, ocular, and central nervous system manifestations, and thus infection can lead to mild to serious or severe morbidity, such as gingivostomatitis, herpes labialis, herpetic whitlow, neonatal herpes, corneal blindness, meningitis, and encephalitis.^{6,9}

HSV-1 can also be transmitted to susceptible persons through oral sex or sexual intercourse resulting in genital herpes, given the genital portal of initial entry.^{3,7,10} Recent evidence from Western countries indicates a growing role for HSV-1 as a sexually transmitted infection (STI) and a leading, if not the leading, cause of genital herpes.^{7,11–15}

With continued improvement in hygiene and living conditions, HSV-1 antibody prevalence (seroprevalence) appears to be declining at least in Western countries.^{1,5,16–22} HSV-1 seroprevalence has declined by about 30% over the last three decades among adolescents 14–19 years of age in the United States.⁸ Evidence suggests that a striking transition in HSV-1 epidemiology, from an oral to increasingly genital infection, is already taking place in Western countries,^{7,8,23} and is resulting in significant clinical and psychosocial morbidity.^{4,7,23–25}

In context of limited data on HSV-1 seroprevalence in MENA,¹ the aim of our study was to assess HSV-1 seroprevalence among select MENA national populations and to characterize the infection's age-distribution. Specifically, we assessed HSV-1 seroprevalence among male blood donors, from 11 MENA nationalities, who are currently residing in Qatar. Qatar is a MENA country situated in the Arabian Peninsula with a population of 2.2 million in 2014.²⁶ Qataris constitute only 12% of the total population, with the vast majority of the population being recent short-term expatriate residents coming for contractual employment for specific number of years.²⁶

With a large fraction of these expatriates coming from other MENA countries, Qatar provided an opportune setting for a comparative study of HSV-1 seroprevalence among different MENA populations. HSV-1 seroprevalence among these expatriates should be comparable to HSV-1 seroprevalence in their home countries. These expatriates are predominantly recent short-term residents in Qatar and spent most of their lifetime in their home countries—their seroprevalence should be more representative of the exposure risk in their home countries, rather than in Qatar. HSV-1 seroprevalence among men should also be representative of that among women, as existing global evidence suggests no major sex-specific differences.^{1,2} Since HSV-1 is mainly transmitted orally with a general-population epidemiology, we would further expect that the seroprevalence among blood donors should be comparable to that in the wider population, as supported also by existing evidence.¹

2 | MATERIALS AND METHODS

2.1 | Study design and participants

This was an opportunistic cross-sectional study on volunteer blood donors from different MENA nationalities attending

Hamad Medical Corporation, the main healthcare provider in Qatar, between June 2013 and June 2016. Blood donation in Qatar is a common practice, and individuals from diverse socioeconomic strata participate in blood donation campaigns. A total of 5,973 blood donors consented to provide blood specimens and basic demographic information including nationality, age, and sex. No identifiable information was collected. The blood specimens were collected for other studies,^{27–30} but remaining specimens were used for this study. The research work was approved by the ethics boards and research committees at Qatar University, Hamad Medical Corporation, and Weill Cornell Medicine-Qatar.

The sample comprised Qataris and expatriates (MENA and non-MENA nationals) residing in Qatar, men and women, and adults ≥ 18 years of age. The sample included 5,799 men and 152 women, with gender missing for 22 subjects. The number of female participants was small and consequently women were excluded. All specimens from non-MENA male nationals ($n = 1,295$) were also excluded. An additional MENA specimen ($n = 1$) was omitted due to missing gender information. The remaining 4,525 MENA specimens served as the original sampling cohort for selection of the final sample.

Final sample sizes were calculated for a significance level of $\alpha = 0.05$. Sample size of 50 was estimated for each 5-year age group in each country to assess an age-specific HSV-1 seroprevalence of 88% with a 10% precision level. Sample size of 200 was estimated for each country to assess the country's overall HSV-1 seroprevalence of 88% with a 5% precision level. The 88% seroprevalence was based on observed HSV-1 seroprevalence in a study from Saudi Arabia,³¹ also a MENA country.

For estimating HSV-1 age-specific seroprevalence, a random sample of 50 subjects per age group was selected for each of Egypt, the Fertile Crescent (Iraq, Jordan, Lebanon, Palestine, and Syria), and Qatar (Table 1). If serum was not sufficient for a subject, a replacement subject was randomly chosen with the same nationality and age group. There were not always sufficient subjects or serum to conduct the serology to reach the 50 target sample size per age category. Due to insufficient sample size in each country individually, the neighboring countries of Iraq, Jordan, Lebanon, Palestine, and Syria were merged together as one national unit, the Fertile Crescent, as they share similar socio-economic and socio-cultural attributes. No sufficient sample size was available to assess the age-specific seroprevalence in other countries.

For estimating country-specific HSV-1 seroprevalence in countries where we did not have sufficient sample size to estimate the age-specific seroprevalence, a random sample of 200 subjects was selected for each of Jordan, Pakistan, Palestine, and Syria. For Iran, Lebanon, Sudan, and Yemen, all available specimens were included in the study sample, as < 200 were available for each of these countries (Table 1). For countries with < 100 subjects, no country-specific estimate was conducted (Algeria, Iraq, Morocco, Oman, and Tunisia).

TABLE 1 Stratification of samples by nationality

	Original sample size N = 4,525	Studied sample size N = 2,077
Male populations with sample size $\geq 200^*$		
Egypt	1001	358 ^a
Jordan	367	200
Pakistan	231	200
Palestine	309	200
Qatar	1130	400
Syria	776	200
Male populations with $100 \leq$ sample size ≤ 200		
Iran	115	113 ^b
Lebanon	118	118
Sudan	132	129 ^b
Yemen	152	148 ^b
Other populations with sample size < 100		
Iraq	43	11
Other	151	0

*Sample was randomly selected.

^aOnly 39 and 19 sera were available for age groups 50-54 and ≥ 55 , respectively.

^bNot enough serum for serology testing.

2.2 | Biological sample collection and laboratory analysis

A portion of sera (50 μ L) was aliquoted from existing sera samples that were stored at -80°C until used for serology testing. Sera were tested for the presence of anti-HSV-1 IgG using HerpeSelect[®] 1 enzyme linked immunosorbent assay (ELISA) kits (Cat. No. EL0910G-5, Focus Diagnostics). This kit was designed for qualitative detection of type-specific IgG antibodies to HSV-1 in human serum using a 96-microwell polystyrene plate coated with

TABLE 2 Estimates of HSV-1 country-specific seroprevalence among male blood donors currently residing in Qatar but from different Middle East and North African countries

Country	Sample size	Seroprevalence N +, (%)	Seroprevalence 95% CI
Egypt	358	349 (97.5)	95.3-98.7
Iran	113 ^a	92 (81.4)	73.3-87.5
Jordan	200	173 (86.5)	81.0-90.5
Lebanon	118	96 (81.4)	73.4-87.4
Pakistan	200	154 (77.0)	70.7-82.3
Palestine	200	161 (80.5)	74.2-85.2
Qatar	400	329 (82.3)	78.2-85.7
Sudan	129	117 (90.7)	84.5-94.6
Syria	200	177 (88.5)	83.9-92.6
Yemen	148	137 (92.6)	87.2-95.8

^aOne final equivocal HSV-1 result.

a purified recombinant HSV-1 glycoprotein-G antigen (gG1). The kit was approved for laboratory diagnosis of anti-HSV-1 IgG by the US Food and Drug Administration.³²

Analysis and results were interpreted according to the manufacturer's instructions: sera with optical density index values (cut-off) < 0.90 were considered negative, values > 1.10 were considered positive, and values ranging between 0.90 and 1.10 were considered equivocal.³² All equivocal specimens were retested. Those that remained equivocal were reported as equivocal.

2.3 | Data analysis

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 24. Age was categorized into eight 5-year bands: ≤ 24 , 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, and ≥ 55 . Cross-tabulation between age and HSV-1 serostatus was performed for Egypt, the Fertile Crescent, and Qatar to describe the age-specific HSV-1 seroprevalence of the study population. Trends were assessed using the Cochran-Armitage test for trend. Robust Poisson regression³³ was conducted to estimate the crude and adjusted effects of age and nationality on HSV-1 seroprevalence. Significance level was defined at $\alpha = 0.05$.

3 | RESULTS

In total, 2,077 serum specimens from subjects from 11 MENA countries were tested for HSV-1 antibodies (Table 1). The median age among those tested was 37 years. Serological testing identified 1,796 sera as positive, 280 as negative, and one as equivocal.

The country-specific overall HSV-1 seroprevalence among males was estimated for 10 MENA national populations. The highest seroprevalence was among Egyptians at 97.5% (95% CI 95.3-98.7%), and the lowest among Pakistanis at 77.0% (95% CI 70.7-82.3%). Seroprevalence for all national populations is presented in Table 2.

The age-specific HSV-1 seroprevalence was estimated for Egyptians, nationals of the Fertile Crescent (Iraq, Jordan, Lebanon, Palestine and Syria), and Qataris (Table 3). Among Egyptians, HSV-1 seroprevalence was $> 90\%$ in all age groups, with no evidence for growing or declining trend with age (p -value for trend = 0.259). Among Fertile Crescent nationals, HSV-1 seroprevalence increased steadily with age starting from 70.0% (95% CI 56.3-80.9%) among those aged ≤ 24 years up to 98.0% (95% CI 89.5-99.7%) among those aged ≥ 55 years (p -value < 0.001). Among Qataris, HSV-1 seroprevalence also increased with age (p -value < 0.001), and was lowest at 62.0% (95% CI 48.2-74.1%) among those aged 25-29 years.

Both age and nationality were found to be associated factors with HSV-1 infection in both univariable and multivariable analyses (Table 4). There was a significant positive association between seroprevalence and age in the univariable analysis. Compared to those aged ≤ 24 years, all older age groups had higher seroprevalence.

TABLE 3 Estimates of HSV-1 age-specific seroprevalence among male blood donors currently residing in Qatar but from Egypt, the Fertile Crescent (including Iraq, Jordan, Lebanon, Palestine, and Syria), and Qatar

Age group	Egypt			Fertile Crescent			Qatar		
	Sample size	Seroprevalence N+, (%)	Seroprevalence 95% CI	Sample size	Seroprevalence N+, (%)	Seroprevalence 95% CI	Sample size	Seroprevalence N+, (%)	Seroprevalence 95% CI
≤ 24 years	50	46 (92.0)	81.2-96.9	50	35 (70.0)	56.3-80.9	50	35 (70.0)	56.3-80.9
25-29 years	50	50 (100.0)	92.9-100.0	50	36 (72.0)	58.3-82.5	50	31 (62.0)	48.2-74.1
30-34 years	50	49 (98.0)	89.5-99.7	50	41 (82.0)	69.2-90.2	50	40 (80.0)	67.0-88.8
35-39 years	50	49 (98.0)	89.5-99.7	50	42 (84.0)	71.5-91.7	50	41 (82.0)	69.2-90.2
40-44 years	50	49 (98.0)	89.5-99.7	50	42 (84.0)	71.5-91.7	50	42 (84.0)	71.5-91.7
45-49 years	50	50 (100.0)	92.9-100.0	50	47 (94.0)	83.8-97.9	50	48 (96.0)	86.5-98.9
50-54 years	39	37 (94.9)	83.1-98.6	50	49 (98.0)	89.5-99.7	50	46 (92.0)	81.2-96.9
≥55 years	19	19 (100.0)	83.2-100.0	50	49 (98.0)	89.5-99.7	50	46 (92.0)	81.2-96.9

The crude prevalence ratios (PRs) increased from 1.11 (95% CI 1.00-1.22) for those aged 25-29 years to 1.32 (95% CI 1.21-1.44) for those aged ≥55 years.

There were also significant differences in seroprevalence with nationality in the univariable analysis. The crude prevalence ratios were significantly higher among Jordanians (PR = 1.12; 95% CI 1.02-1.23), Syrians (PR = 1.15, 95% CI 1.05-1.26), Sudanese (PR = 1.18, 95% CI 1.07-1.29), Yemenis (PR = 1.20, 95% CI 1.10-1.31), and Egyptians (PR = 1.27, 95% CI 1.17-1.37), compared to Pakistanis.

Age and nationality remained significantly associated with seroprevalence in the multivariable analysis (Table 4). However, the prevalence ratio for Jordanians (PR = 1.08, 95% CI 0.98-1.15) was no longer significantly different compared to Pakistanis after age adjustment.

4 | DISCUSSION

This is to our knowledge the most comprehensive HSV-1 seroprevalence study of different MENA populations and different age groups. We found that overall seroprevalence remains high, but for most nationalities, at lower levels than expected, based on earlier evidence and historical pattern.^{1,17,34-40} The seroprevalence decline appears to reflect lower seroprevalence among the younger age cohorts in recent time; as much as 30% of those <30 years of age have not been exposed to HSV-1. The high overall HSV-1 seroprevalence in MENA suggests that there may be significant HSV-1-related morbidity in the population at large that needs to be quantified and addressed, including diseases such as gingivostomatitis, herpetic whitlow, corneal blindness, and encephalitis among others.^{6,9}

Our results indicated variation in HSV-1 seroprevalence across countries, and observed rates are consistent with the global evidence suggesting an association between HSV-1 infection and socio-economic status.^{1,8} Seroprevalence was higher in the lower-income countries of Egypt, Sudan, and Yemen, than in the relatively higher-income countries of Iran, Jordan, Lebanon, Palestine, Qatar, and Syria. A recent study from Saudi Arabia, a higher-income country, found also a seroprevalence similar to our results for the higher-income countries.³¹

Pakistan though was a notable exception by being a lower seroprevalence (77%) and also a lower-income country. This finding remains to be confirmed and explained, but we are not aware of other comparable HSV-1 studies from Pakistan. Of note, however, HSV-1 seroprevalence in India, a neighboring country of Pakistan with similar socio-economic level, was reported to be at only 60%.² These results may hint that the association between HSV-1 infection and socio-economic status is more nuanced than previously thought.

Our study has limitations. The specimens were only from male blood donors with no population- and probability-based sampling, exposing the study to potential selection bias. Specimens were collected from individuals of different nationalities, but all individuals were residing in Qatar at that time. HSV-1 seroprevalence among

TABLE 4 Crude and adjusted prevalence ratios (95% confidence intervals) for HSV-1 seroprevalence among 2,077 male blood donors currently residing in Qatar but from different Middle East and North African countries

	Crude prevalence ratio (95% CI)	Adjusted prevalence ratio ^a (95% CI)
Age		
≤ 24 years	Ref	Ref
25-29 years	1.11 (1.00-1.22)	1.10 (1.00-1.21)
30-34 years	1.14 (1.04-1.25)	1.15 (1.05-1.26)
35-39 years	1.22 (1.12-1.34)	1.24 (1.13-1.35)
40-44 years	1.24 (1.13-1.35)	1.25 (1.14-1.36)
45-49 years	1.29 (1.18-1.41)	1.30 (1.19-1.42)
50-54 years	1.32 (1.22-1.44)	1.32 (1.22-1.44)
≥ 55 years	1.32 (1.21-1.44)	1.35 (1.24-1.47)
Nationality		
Pakistan	Ref	Ref
Qatar	1.07 (0.98-1.17)	1.04 (0.95-1.15)
Egypt	1.27 (1.17-1.37)	1.25 (1.16-1.35)
Iran	1.08 (0.96-1.21)	1.06 (0.95-1.19)
Jordan	1.12 (1.02-1.23)	1.08 (0.98-1.18)
Lebanon	1.06 (0.94-1.19)	1.03 (0.92-1.15)
Palestine	1.05 (0.94-1.16)	1.03 (0.93-1.13)
Sudan	1.18 (1.07-1.29)	1.17 (1.07-1.28)
Syria	1.15 (1.05-1.26)	1.15 (1.05-1.26)
Yemen	1.20 (1.10-1.31)	1.21 (1.11-1.31)

^aAdjusted for nationality and age.

these expatriates may not necessarily reflect the seroprevalence in their home countries. Very basic socio-demographic variables were collected, limiting our ability to assess relevant individual-level associations such as education, socio-economic status, or specific socio-cultural practices. Two different methods were used to select the testing samples depending on primary purpose, overall versus age-specific seroprevalence. For the overall seroprevalence, we chose the specimens randomly among all specimens for that nationality. Meanwhile, for the age-specific seroprevalence, we chose a fixed number of specimens (also randomly) for each age group, and then determined the overall seroprevalence in this sample based on the number of positives in all age groups. There is evidence for variation in the sensitivity and specificity of HSV-1 assays by population,^{32,41,42} thereby potentially affecting the estimated seroprevalence levels.

Despite these limitations, selection bias may be less of an issue for HSV-1, as it is predominantly transmitted orally with a general-population epidemiology. In these blood-donor samples, the bias will probably be towards older populations, given that the median age in MENA countries is most often <25 years of age.⁴³ Our estimated seroprevalence could be higher than actual seroprevalence, and our findings are possibly conservative about the extent of seroprevalence decline among youth in recent time. Though all tested individuals were Qatar residents, expatriates are not permanent migrants in Qatar, typically stay for only few years, and the vast majority have moved to Qatar recently thanks to economic expansion over the last decade. The assay used in this study (Focus HerpeSelect[®], Focus Diagnostics) is highly regarded, approved by the United States Food and Drug Administration, and is among the most commonly used herpes assays in the literature.³² Lastly, these limitations should be considered in light of the logistical challenges and prohibitive costs to conduct HSV-1 nationally-representative studies on probability-based samples, limitations in availability of HSV-1 epidemiologic data globally,⁸ and the present opportunity to conduct this large-scale study by country and age group on existing samples. This is the first time HSV-1 seroprevalence data will appear in the literature for several of the included countries.

In conclusion, HSV-1 seroprevalence is high in MENA though with some variation across countries. The seroprevalence appears also to have declined in recent decades, possibly reflecting reduced exposure during childhood. These findings highlight the need for monitoring of trends in HSV-1 seroprevalence, and etiological surveillance of diagnosed genital herpes and HSV-1 related morbidities. These findings argue also for rapid development of prevention interventions to control HSV-1 infection transmission and to prevent the associated clinical disease burden.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the laboratory work and administrative support of Ms Enas Alabsi and Ms Adona Canlas, and the following students for their assistance in performing the anti-HSV-1 ELISA assay testing: Mariam Nofal, Rana Al-Disis, Malaz Comi, Afifah Sahara, and Sana Khan. We are also grateful to Dr Asmaa Al-Marwani, Ms Maria Samatti, and Ms Sana Abohasera for their work on blood specimen collection. The authors are further grateful for infrastructure support provided by the Biostatistics, Epidemiology, and Biomathematics Research Core at Weill Cornell Medicine-Qatar. Testing kits were provided through pilot funding by the Biomedical Research Program at Weill Cornell Medicine-Qatar. GKN acknowledges support by Qatar university internal grant No. QUST-CHS-SPR-15/16-7. LJA and SRD acknowledge study conception and design support through NPRP grant number 9-040-3-008 from the Qatar National Research Fund (a member of Qatar Foundation), and GKN acknowledges support from the Qatar National Research Fund UREP grant number UREP18-001-3-001. The findings achieved herein are solely the responsibility of the authors.


CONFLICTS OF INTEREST


The authors have no conflicts of interest to disclose.

AUTHORS' CONTRIBUTION

LJA, GKN, and SRD designed the study and developed the research methodology. GKN provided the specimens and led the laboratory component of this study including testing of all specimens. LIM conducted laboratory work on the specimens and contributed to data management. SRD conducted the data analysis, interpretation of the results, and wrote the initial draft of the article. LJA conceived the study and led the data analysis, interpretation of the results, and drafting of the article. All authors contributed to the interpretation of the results and drafting and revision of the article.

ORCID

Gheyath K. Nasrallah  <http://orcid.org/0000-0001-9252-1038>

Laith J. Abu-Raddad  <http://orcid.org/0000-0003-0790-0506>

REFERENCES

- Smith J, Robinson N. Age-Specific prevalence of infection with herpes simplex virus types 2 and 1: a global review. *J Infect Dis*. 2002;186: S3–S28.
- Looker KJ, Magaret AS, May MT, et al. Global and regional estimates of prevalent and incident herpes simplex virus type 1 infections in 2012. *PLoS ONE*. 2015;10:e0140765.
- Gnann JW, Whitley RJ. Genital herpes. *N Engl J Med*. 2016;375: 666–674.
- Gupta R, Warren T, Wald A. Genital herpes. *Lancet*. 2007;370: 2127–2137.
- Xu F, Lee FK, Morrow RA, et al. Seroprevalence of herpes simplex virus type 1 in children in the United States. *J Pediatr*. 2007;151:374–377.
- Brady RC, Bernstein DI. Treatment of herpes simplex virus infections. *Antiviral Res*. 2004;61:73–81.
- Bernstein DI, Bellamy AR, Hook EW, 3rd, et al. Epidemiology, clinical presentation, and antibody response to primary infection with herpes simplex virus type 1 and type 2 in young women. *Clin Infect Dis*. 2013;56:344–351.
- Bradley H, Markowitz LE, Gibson T, McQuillan GM. Seroprevalence of herpes simplex virus types 1 and 2—United States, 1999–2010. *J Infect Dis*. 2014;209:325–333.
- Fatahzadeh M, Schwartz RA. Human herpes simplex virus infections: epidemiology, pathogenesis, symptomatology, diagnosis, and management. *J Am Acad Dermatol*. 2007;57:737–763. quiz 764–736.
- Ryder N, Jin F, McNulty AM, Grulich AE, Donovan B. Increasing role of herpes simplex virus type 1 in first-episode anogenital herpes in heterosexual women and younger men who have sex with men, 1992–2006. *Sex Transm Infect*. 2009;85:416–419.
- Lowhagen GB, Tunback P, Andersson K, Bergstrom T, Johansson G. First episodes of genital herpes in a Swedish STD population: a study of epidemiology and transmission by the use of herpes simplex virus (HSV) typing and specific serology. *Sex Transm Infect*. 2000;76:179–182.
- Nilsen A, Myrmet H. Changing trends in genital herpes simplex virus infection in Bergen, Norway. *Acta Obstet Gynecol Scand*. 2000;79: 693–696.
- Samra Z, Scherf E, Dan M. Herpes simplex virus type 1 is the prevailing cause of genital herpes in the Tel Aviv area, Israel. *Sex Transm Dis*. 2003;30:794–796.
- Gilbert M, Li X, Petric M, et al. Using centralized laboratory data to monitor trends in herpes simplex virus type 1 and 2 infection in British Columbia and the changing etiology of genital herpes. *Can J Public Health*. 2011;102:225–229.
- Roberts CM, Pfister JR, Spear SJ. Increasing proportion of herpes simplex virus type 1 as a cause of genital herpes infection in college students. *Sex Transm Dis*. 2003;30:797–800.
- Xu F, Sternberg MR, Kottiri BJ, et al. Trends in herpes simplex virus type 1 and type 2 seroprevalence in the United States. *JAMA*. 2006;296:964–973.
- Kramer MA, Uitenbroek DG, Ujcic-Voortman JK, et al. Ethnic differences in HSV1 and HSV2 seroprevalence in Amsterdam, the Netherlands. *Euro Surveill*. 2008;13:717–727.
- Wutzler P, Doerr HW, Farber I, et al. Seroprevalence of herpes simplex virus type 1 and type 2 in selected German populations—relevance for the incidence of genital herpes. *J Med Virol*. 2000;61:201–207.
- Sauerbrei A, Schmitt S, Scheper T, et al. Seroprevalence of herpes simplex virus type 1 and type 2 in Thuringia, Germany, 1999 to 2006. *Euro Surveill*. 2011;16:20005.
- Pebody RG, Andrews N, Brown D, et al. The seroepidemiology of herpes simplex virus type 1 and 2 in Europe. *Sex Transm Infect*. 2004;80:185–191.
- Aarnisalo J, Ilonen J, Vainionpaa R, Volanen I, Kaitosaari T, Simell O. Development of antibodies against cytomegalovirus, varicella-zoster virus and herpes simplex virus in Finland during the first eight years of life: a prospective study. *Scand J Infect Dis*. 2003;35:750–753.
- Vyse AJ, Gay NJ, Slomka MJ, et al. The burden of infection with HSV-1 and HSV-2 in England and Wales: implications for the changing epidemiology of genital herpes. *Sex Transm Infect*. 2000;76:183–187.
- Whitley RJ. Changing epidemiology of herpes simplex virus infections. *Clin Infect Dis*. 2013;56:352–353.
- Mark H, Gilbert L, Nanda J. Psychosocial well-being and quality of life among women newly diagnosed with genital herpes. *J Obstet Gynecol Neonatal Nurs*. 2009;38:320–326.
- Mindel A. Psychological and psychosexual implications of herpes simplex virus infections. *Scand J Infect Dis Suppl*. 1996;100:27–32.
- Ministry of Development Planning and Statistics. Qatar's Fourth National Human Development Report: Realising Qatar National Vision 2030, The Right to Development (Available at: http://hdr.undp.org/sites/default/files/qatar_nhdr4_english_15june2015.pdf). Ministry of Development Planning and Statistics;2015.
- AbuOdeh R, Al-Mawlawi N, Al-Qahtani AA, et al. Detection and genotyping of torque teno virus (TTV) in healthy blood donors and patients infected with HBV or HCV in Qatar. *J Med Virol*. 2015;87: 1184–1191.
- AbuOdeh RO, Al-Absi E, Ali NH, et al. Detection and phylogenetic analysis of human pegivirus (GBV-C) among blood donors and patients infected with hepatitis B virus (HBV) in Qatar. *J Med Virol*. 2015;87: 2074–2081.
- Al-Qahtani AA, Alabsi ES, AbuOdeh R, Thalib L, Nasrallah GK. Prevalence of anelloviruses (TTV, TTMDV, and TTMV) in healthy blood donors and in patients infected with HBV or HCV in Qatar. *Virology*. 2016;13:208.
- Nasrallah GK, Al Absi ES, Ghandour R, et al. Seroprevalence of hepatitis E virus among blood donors in Qatar (2013–2016). *Transfusion (Paris)*. 2017;57:1801–1807.
- Memish ZA, Almasri M, Chentoufi AA, et al. Seroprevalence of herpes simplex virus type 1 and type 2 and coinfection with HIV and syphilis:

- the first national seroprevalence survey in Saudi Arabia. *Sex Transm Dis.* 2015;42:526–532.
32. Diagnostics F. *HerpeSelect 1 ELISA IgG (English)*. 2011.
 33. Petersen MR, Deddens JA. A comparison of two methods for estimating prevalence ratios. *BMC Med Res Methodol.* 2008;8:9.
 34. Nahmias AJ, Lee FK, Beckman-Nahmias S. Sero-epidemiological and –sociological patterns of herpes simplex virus infection in the world. *Scand J Infect Dis Suppl.* 1990;69:19–36.
 35. Cowan FM, French RS, Mayaud P, et al. Seroepidemiological study of herpes simplex virus types 1 and 2 in Brazil, Estonia, India, Morocco, and Sri Lanka. *Sex Transm Infect.* 2003;79:286–290.
 36. Dolar N, Serdaroglu S, Yilmaz G, Ergin S. Seroprevalence of herpes simplex virus type 1 and type 2 in Turkey. *J Eur Acad Dermatol Venereol.* 2006;20:1232–1236.
 37. Ibrahim A, Kouwatli K, Obeid M. Frequency of herpes simplex virus in Syria based on type-specific serological assay. *Saudi Med J.* 2000;21: 355–360.
 38. Ghazi HO, Telmesani AM, Mahomed MF. TORCH agents in pregnant Saudi women. *Med Princ Pract.* 2002;11:180–182.
 39. Nizami D. Serological evaluation of HSV-1 and HSV-2 infection In pregnancy. *Turk J Med Sci.* 2003;34:97–101.
 40. Hossain A. Herpes simplex virus type 1 (HSV-1) and varicellazoster virus (VZV) infections in Saudi Arabia. *J Trop Pediatr.* 1989;35:171–174.
 41. Ashley-Morrow R, Nollkamper J, Robinson NJ, Bishop N, Smith J. Performance of focus ELISA tests for herpes simplex virus type 1 (HSV-1) and HSV-2 antibodies among women in ten diverse geographical locations. *Clin Microbiol Infect.* 2004;10:530–536.
 42. Mark HD, Nanda JP, Roberts J, Rompalo A, Melendez JH, Zenilman J. Performance of focus ELISA tests for HSV-1 and HSV-2 antibodies among university students with no history of genital herpes. *Sex Transm Dis.* 2007;34:681–685.
 43. United Nations Department of Economic and Social Affairs. World Population Prospects, the2015 Revision. 2015.

How to cite this article: Nasrallah GK, Dargham SR, Mohammed LI, Abu-Raddad LJ. Estimating seroprevalence of herpes simplex virus type 1 among different Middle East and North African male populations residing in Qatar. *J Med Virol.* 2018;90:184–190. <https://doi.org/10.1002/jmv.24916>