Original Article

Impact of Heads-Up Display Use on Ophthalmologist Productivity, Wellness, and Musculoskeletal Symptoms: A Survey Study

Nicholas E. Tan[1], Brayden T. Wortz[2], Eric D. Rosenberg[3], Nathan M. Radcliffe[4,5], Preeya K. Gupta[6,7]

[1]Department of Ophthalmology, College of Medicine, State University of New York Downstate Health Sciences University, Brooklyn, NY, USA, [2]Department of Chemistry, Wake Forest University, Winston-Salem, NC, USA, [3]Department of Ophthalmology, New York Medical College, Valhalla, NY, USA, [4]Department of Ophthalmology, Mount Sinai School of Medicine, New York, NY, USA, [5]New York Eye Surgery Center, Bronx, NY, USA, [6]Triangle Eye Consultants, Raleigh, NC, USA, [7]Tulane University, New Orleans, LA, USA

Abstract

Purpose: To explore how ophthalmologist productivity, wellness, and musculoskeletal (MSK) symptoms are affected by heads-up display (HUD) use.

Methods: A digital survey was emailed to the United States ophthalmologists. Questions covered topics including MSK health, surgical output, work hours, wellness hours, and factors related to HUD use.

Results: One hundred and forty-four ophthalmologists responded, and 99 completed all eligible questions. HUDs were utilized by 33 respondents, 29 of whom submitted complete surveys. HUD users worked 353 more hours annually ($P = 0.01$) and performed 673 more cases ($P = 0.07$) than nonusers. MSK symptom presence ($P = 0.79$), severity ($P = 0.80$), and frequency ($P = 0.86$) were independent of use. Over half ($n = 16/29$) of users identified symptomatic improvement attributable to the device, mostly in the cervical and lumbar regions. Mean job stress was moderate-severe for both users and nonusers ($P = 0.10$), and there was no significant difference in wellness hours ($P = 0.44$). Retina specialists ($P = 0.02$) and males ($P = 0.03$) were more likely to have operated with the technology. Nearly half of heads-up surgeons ($n = 12/29$) had obtained new equipment to target MSK symptoms, versus 1.4% of nonusers ($n = 1/70$; $P = 0.0009$). Most of those who operated with HUDs would recommend them to others (69.0%, $n = 20/29$), but 44.8% ($n = 13/29$) indicated ergonomic challenges. Primary concerns included awkward viewing angles, setup difficulties, and a lack of access.

Conclusions: HUD surgeons reported greater work output versus nonusers without significant compromises in wellness or MSK health. User feedback suggests that the technology may lessen neck and low back pains, but barriers including cost and system inconveniences may impede adoption.

Keywords: Ergonomics, Heads-up display, Productivity, Three-dimensional visualization system, Wellness

Address for correspondence: Preeya K. Gupta, 2075 Renaissance Park Pl, Cary, NC, USA.
E-mail: preeyakgupta@gmail.com
Submitted: 08-Apr-2022; **Revised:** 08-May-2022; **Accepted:** 12-May-2022; **Published:** 30-Nov-2022

Introduction

Ophthalmologists report major occupational stressors relating to factors such as administrative burdens, high patient volume, and frequent musculoskeletal (MSK) complaints.[1-4] In a few previous surveys, eye specialists were asked about measures taken to improve their well-being. One study reported mean exercise allocation of 3.34 h/week among ophthalmologists and another noted that 33% exercised thrice weekly, with only

Access this article online

Quick Response Code:

Website: www.jcurrophthalmol.org

DOI: 10.4103/joco.joco_115_22

How to cite this article: Tan NE, Wortz BT, Rosenberg ED, Radcliffe NM, Gupta PK. Impact of heads-up display use on ophthalmologist productivity, wellness, and musculoskeletal symptoms: A survey study. J Curr Ophthalmol 2022;34:305-11.

the latter study finding a difference in pain symptoms based on the volume.[5,6] Other typical interventions have included measures such as over-the-counter analgesics, bed rest, and physical manipulations.[7]

From a survey of mostly high-volume ophthalmologists in the United States, it was found that 81.4% of participants experienced episodes of pain, discomfort, or disability.[8] Respondents endorsed moderate-to-severe work-related stress on average, which was significantly linked to the extent of their symptoms. In response to MSK complaints, the most selected actions were physical maneuvers such as stretching, exercise, and operating room (OR) postural adjustments.[8]

Recently, two additional survey studies explored the utility of 3D-visualization systems/heads-up displays (HUDs) as a novel method to enhance the occupational experiences of ophthalmologists.[9,10] Both studies found high satisfaction with the devices and positive ergonomic effects. HUD systems provide surgeons with a forward-facing alternative to traditional analog microscopes, making use of a high-definition display mounted on a headset or external monitor. Such devices offer the benefit of decreased anterior cervical flexion and have shown good surgeon and patient outcomes in small-scale studies of both anterior and posterior segment surgery.[11,12] The primary goal of the current study was to expand upon prior research by examining how HUD use may broadly impact the ophthalmic surgeon experience in areas including MSK complaints, wellness, and practice output. Secondarily, we sought to identify current barriers to HUD adoption.

Methods

Sterling Institutional Review Board (Atlanta, GA) ruled that approval was not required for this cross-sectional digital survey study. The survey from which the current paper's findings are derived is the same survey described in a previous publication.[8] Implied consent was obtained by informing participants of the purpose, data usage, anonymity, and voluntariness of the study preceding survey administration. No incentives were provided, and participants could exit the survey at any time. All study procedures were followed in accordance with the ethical standards set by Sterling IRB and the standards set by the 1975 Declaration of Helsinki and its revisions in 2000.

A questionnaire designed on SurveyMonkey was sent via email from August 2020 to January 2021 to ophthalmologists practicing in any of four domains: comprehensive, cornea, glaucoma, and retina. Emails were acquired from academic departments, the authors' individual networks, and professional ophthalmology groups. The full questionnaire is included in the supplemental material of a previous publication.[8] Questions covered HUD use, demographics, work hours, procedural volumes, self-reported job stress, exercise, mindfulness and meditation, MSK health, ergonomics, and the Total Disability Index (TDI). Self-reported job stress was rated on a seven-point Likert scale with one being "not stressful at all", four indicating "moderately stressful", and seven as "extremely stressful". The TDI is a statistically validated measured of disability from back and neck pain, scored out of 100%.[13] Higher percentages indicate worse disablement. Questions that asked for information across the span of 1 year were framed in terms of the pre-COVID February 2019–2020 period.

Using SurveyMonkey's question-piping function, respondents received different questions depending on whether they selected 3D-visualization system/HUD as a tool used for eye surgery. HUD users were asked about HUD type, extent of use, effects on pain and operating volume, ergonomic challenges, and their opinion on recommending HUD to other eye surgeons. Seven-point Likert scales with accompanying text ranging from "significantly decreases" or "strongly advise against" to "significantly increases" or "strongly recommend" were used for the pain and recommendation questions. Nonusers were asked to select reasons for why they did not adopt the technology. A goal of at least 30 HUD user respondents was set for the survey before performing data analysis.

Descriptive statistics and significance testing were computed using GraphPad Prism for Mac (v. 8, GraphPad Software) and Statistical Package for the Social Sciences for Mac (v. 27, IBM). Continuous data was recorded as mean ± standard deviation. Demographic factors, total surgical volume in a year, total hours worked in a year, MSK symptom characteristics, TDI scores, and job stress scores were each compared between HUD users and nonusers. Race was analyzed with Chi-square, while dichotomous outcomes were analyzed using Fisher's exact test. For continuous variables such as total surgical volume, Shapiro–Wilk testing assessed normality. Normally distributed outcomes were analyzed with *t*-test, while abnormally distributed variables required the Mann–Whitney U-test. Ordinal regression was applied to two outcomes: frequency of MSK pain episodes and job stress scores. Significance was set at two-sided $P < 0.05$.

Results

For the survey, 245 ophthalmologists were contacted. This is the same population as described in the previous publication.[8] Specifically, 58.8% (n = 144) of those contacted identified demographics, 52.2% (n = 128) completed the initial HUD use screening question, and 40.4% (n = 99) answered all eligible questions. Of the 128 respondents who answered the HUD question, the average age was 50.6 ± 10.8 years, 28.1% (n = 36) were nonwhite, and 22.7% (n = 29) were women. The most commonly chosen specialty of those 128 respondents was cornea (47.7%, n = 61), while retina was the least common (7.8%, n = 10). HUD was utilized by 25.8% of respondents (n = 33) in the February 2019–February 2020. The NGENUITY system (Alcon, Forth Worth, TX, USA) was the primary HUD type for 75.8% (n = 25), while the ARTEVO 800 (Zeiss, Oberkochen, Germany) was the primary HUD type for 24.2% (n = 8). Later in the survey, further user-specific questions were answered by 29 respondents;

four of the original 33 HUD surgeons dropped out. Seventy nonusers answered the question on obstacles to HUD adoption. Comparisons between HUD users and non-HUD users are compiled in Table 1.

For those who operated with HUD, an average of 37.2 ± 39.3% of their cases were performed utilizing the technology. Surgeons had experience with HUD for a mean duration of 41.5 ± 47.0 months. Retina specialization was significantly associated with HUD use (P = 0.02), with 60.0% of such specialists (n = 6/10) reporting operation of such devices. HUD use was independent of comprehensive (P = 0.22), cornea (P = 0.84), or glaucoma (P = 0.12) specialization. Male respondents (P = 0.03) were more likely to have tried HUD, with only 9.1% (n = 3/33) of HUD users being female. HUD adoption was independent of age (P = 0.89), years in practice (P = 0.92), and race (P = 0.96). Interest in ergonomics (P = 0.34) and exposure to ergonomic strategies (P = 0.58) were each not associated with HUD use. Thirty HUD surgeons and 81 non-HUD surgeons responded to questions relating to case volume and work hours. HUD surgeons on average performed a 68.2% (n = 673 cases) greater volume of OR cases in 1 year compared to surgeons who did not utilize HUD, though this difference was nonsignificant (P = 0.07). They also worked an average of 17.2% (n = 353 h) more in 1 year than nonusers, a significant difference (P = 0.01). Of HUD users, 62.1% (n = 18/29)

Table 1: Comparison of ophthalmologists who used heads-up display with nonusers

Parameter	HUD users (n=33 total)	Non-HUD users (n=95 total)	P
Age (mean years±SD)	49.3±9.4	49.6±10.4	0.89*
Race/ethnicity, n (%)			
White	23 (69.7)	69 (72.6)	0.96†
Asian	7 (21.2)	19 (20.0)	
Black	1 (3.0)	3 (3.2)	
Hispanic	1 (3.0)	3 (3.2)	
Other	1 (3.0)	1 (1.1)	
Female, n (%)	3 (9.1)	26 (27.4)	0.03‡
Years in practice (mean±SD)	20.3±9.5	20.5±10.3	0.92*
Subspecialization§, n (%)			
Comprehensive	10 (30.3)	42 (44.2)	0.22‡
Cornea	15 (45.5)	46 (48.4)	0.84‡
Glaucoma	6 (18.2)	32 (33.7)	0.12‡
Retina	6 (18.2)	4 (4.2)	0.02‡
Hours worked in 1 year (mean±SD) [30 HUD, 81 non-HUD respondents]	2399.4±637.9	2046.6±449.3	0.01*
Surgical cases in 1 year (mean±SD) [30 HUD, 81 non-HUD respondents]	1660.5±1576.3	987.2±904.2	0.07‖
Presence of MSK symptoms, n (%) [29 HUD, 70 non-HUD respondents]	23 (79.3)	57 (81.4)	0.79‡
Frequency of MSK symptoms, n (%) [29 HUD, 70 non-HUD respondents]			
None	6 (20.7)	13 (18.6)	0.86¶
Less frequent than once every few months	2 (6.9)	4 (5.7)	
Once every few months	3 (10.3)	10 (14.3)	
Monthly	5 (17.2)	9 (12.9)	
Weekly	7 (24.1)	20 (28.6)	
Daily	6 (20.7)	14 (20.0)	
Total duration of MSK symptoms (mean months±SD) [29 HUD, 70 non-HUD respondents]	104.7±140.6	85.8±106.8	0.79‖
Total disability index score (mean %±SD) [29 HUD, 70 non-HUD respondents]	6.3±7.4	5.8±6.9	0.80‖
Job stress rating** (mean±SD) [29 HUD, 70 non-HUD respondents]	4.9±1.4	4.7±1.1	0.10¶
Weekly hours of exercise and meditation/mindfulness (mean±SD) [29 HUD, 70 non-HUD respondents]	6.2±3.4	7.0±8.6	0.44‖

*Student's t-test, †Pearsons's Chi-square, ‡Fisher's exact test, §Respondents could choose more than one subspecialty, ‖Mann-Whitney U-test, ¶Ordinal regression, **Ranked from 1 (not stressful at all) to 7 (extremely stressful). Due to survey dropout, not all respondents answered each question. In cases where the number of respondents was lower than for the demographic questions, respondents per group are indicated in brackets. HUD: Heads-up display, MSK: Musculoskeletal, SD: Standard deviation believed that they could perform more surgeries on days during which they used HUD instead of traditional analog oculars. The average self-reported percent increase in case load among the 18 surgeons was 14.4 ± 28.5%. Those physicians attributed the increases primarily to HUD use being less fatiguing (94.4%, *n* = 17/18). Moreover, 22.2% (*n* = 4/18) felt that HUD was more time efficient.

Among respondents, the least selected workplace interventions for preventing and/or improving MSK symptoms included modifying existing equipment (15.2%, *n* = 15/99) and adding new equipment (13.1%, *n* = 13/99). Adding new equipment to address MSK symptoms was endorsed by 41.4% of HUD users (*n* = 12/29) compared to only 1.4% of nonusers (*n* = 1/70; *P* = 0.0009). For HUD surgeons, 55.2% (*n* = 16/29) reported that the technology improved their MSK symptoms. The most common locations of improvement for those 16 respondents were in the cervical (44.8%, *n* = 13), lumbar (27.6%, *n* = 8), and thoracic (13.8%, *n* = 4) spines [Figure 1]. Compared to when they used analog oculars, 69.0% (*n* = 20/29) and 58.6% (*n* = 17/29) found HUD use to decrease pain while operating and outside the OR, respectively. One respondent reported moderately increased pain from HUD in the OR setting and outside the OR, while a second respondent indicated moderately increased pain only outside the OR. Among those reporting any symptomatic improvement, it took a mean of 3.8 ± 4.3 months of HUD experience to notice a difference. There were no significant differences between the HUD group and the non-HUD group in terms of the presence of MSK symptoms (*P* = 0.79), frequency of symptoms (*P* = 0.86), total duration of symptoms (*P* = 0.79), and TDI score (*P* = 0.80). Moreover, there were no significant associations between HUD use and weekly exercise and mindfulness/meditation hours (*P* = 0.44) or self-reported job stress rating (*P* = 0.10). Both groups had mean stress scores that exceeded the "moderately stressful" threshold (4.9 ± 1.4 for HUD users vs. 4.7 ± 1.1 for nonusers).

Overall, 69.0% (*n* = 20/29) of HUD surgeons would recommend the technology to other ophthalmologists, with 44.8% (*n* = 13/29) indicating a strong recommendation [Figure 2]. One user selected that they would advise against adopting HUD, and 44.8% (*n* = 13/29) of users indicated ergonomic challenges, difficulties, or inconveniences. From their free text descriptions, two major themes arose: awkward viewing angles and positioning (53.8% of comments, *n* = 7/13) and OR setup difficulties (38.5% of comments, *n* = 5/13). Sample quotes from respondents that characterize each theme are noted in Table 2. The one respondent who advised against HUD referenced problematic positioning, writing, "When using HUD I have to lean around the scope component, and am tilted sideways. It is much less comfortable and has been very disappointing". The other user who had previously indicated that HUD use only increased pain outside the OR setting wrote "coccydynia" as a complaint. As for the 70 nonusers who responded, their most cited reasons for nonadoption were a lack of access to the technology at their surgical sites (71.4%, *n* = 50) and a lack of problems or inconveniences

Table 2: Ergonomic difficulties with ophthalmic heads-up display systems

Theme	Relevant comments
Awkward viewing angles and positioning	"You have to look slightly off angle to visualize the screen"
	"Operating temporally and positioning patient"
	"There is a learning curve associated with looking right while operating as usual"
Operating room setup difficulties	"We have to move the room around when we switch from right to left eyes"
	"Staff resistance to setting up equipment and learning a new system"
	"Operating room flow"
Other	"Coccydynia"

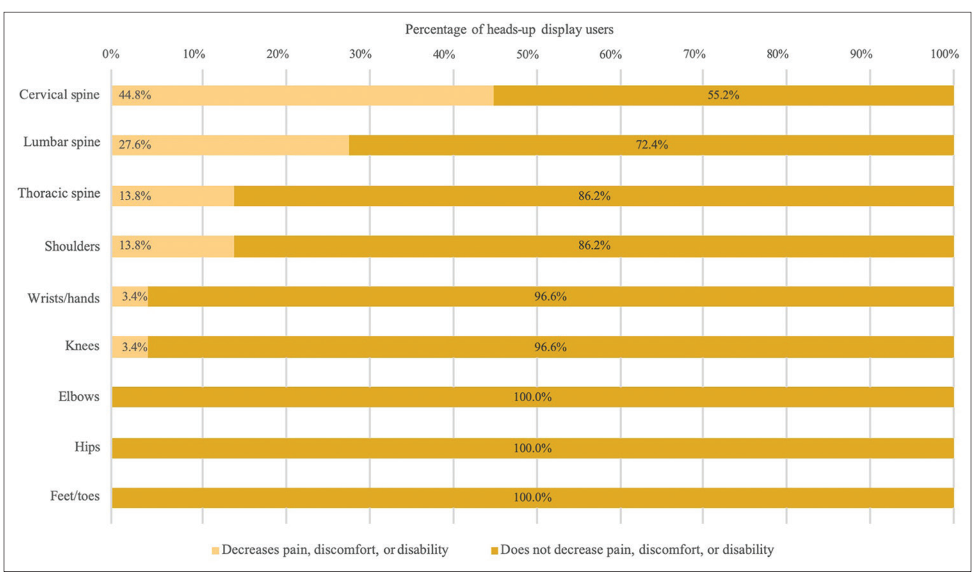

Figure 1: Effects of heads-up display use on region-specific musculoskeletal symptoms

that HUDs would solve (18.6%, $n = 13$). A few respondents were concerned about latency and technical glitches (10.0%, $n = 7$) and ergonomic pitfalls (8.6%, $n = 6$). Further reasons are described in Figure 3.

Discussion

In a sample with a high mean surgical volume and a high prevalence of MSK complaints, HUD systems were found to potentially offer benefits in both domains. There were sizeable differences in total surgical output and total hours worked when comparing users to nonusers, with HUD surgeons performing around 673 more cases and working approximately 353 more hours in a year. Only the latter was a statistically significant difference, but the former approached significance at $P = 0.07$. Despite differences in volume, HUD users did not report greater presence, frequency, or duration of MSK symptoms, and scored similarly to nonusers on a validated metric of total spine disability. They also maintained a comparable amount of wellness activities with a nonsignificant difference in stress

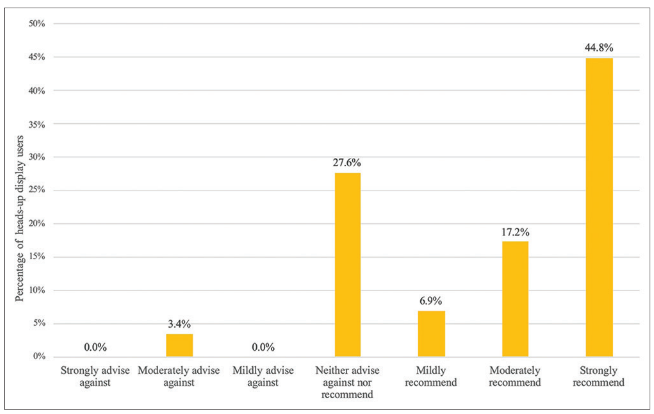

Figure 2: What heads-up display users would tell peers about the technology

scores. We concur with Bin Helayel *et al*., who interpreted a lack of difference in pain between groups despite increased surgical volume in HUD users as suggestive of the technology's ergonomic advantage.[9] Over half of the current study's HUD user respondents reported that the technology reduced their MSK pain, particularly in the spine. The frequency with which the sample made postural adjustments in the OR (67.7%)[8] may further indicate a need for a more ergonomic operating position at baseline. These results are supported by previous studies that have found HUD to be a more comfortable, ergonomic alternative to traditional oculars.[14-16] Satisfaction was also high, with 69.0% of users willing to recommend the technology. Given that back and neck issues appear endemic to the field,[3,5-7] HUD systems may provide a novel avenue for eye surgeons to pursue MSK prophylaxis.

Interestingly, self-perceptions of volume advantages were more modest than the raw case and hour load differences would suggest. Of the 62.1% who felt that their surgical output increased on days with HUD, they noted a mean increase of only 14.4%. There are a few possible explanations for this discrepancy. HUD may not significantly truncate individual surgical case duration, as has been observed in comparisons against standard analog microscopes in cataract and retinal surgeries.[12,17-19] Only 22.2% of respondents in our study who reported increased volume with HUD found the device to be more time-efficient. However, the MSK benefits HUDs provide could enable surgeons to operate for longer and on more days due to enhanced physical endurance. This is supported by nearly two-thirds of respondents finding HUD use to reduce pain inside the OR, and over half reporting less pain outside the OR. Moreover, nearly all of those who felt that they could operate more with HUD selected decreased fatigue as a benefit, which ties to improvements in comfort and mental performance reported in prior research.[10,12] Another possibility is that surgeons in this study who worked more from the onset were the same

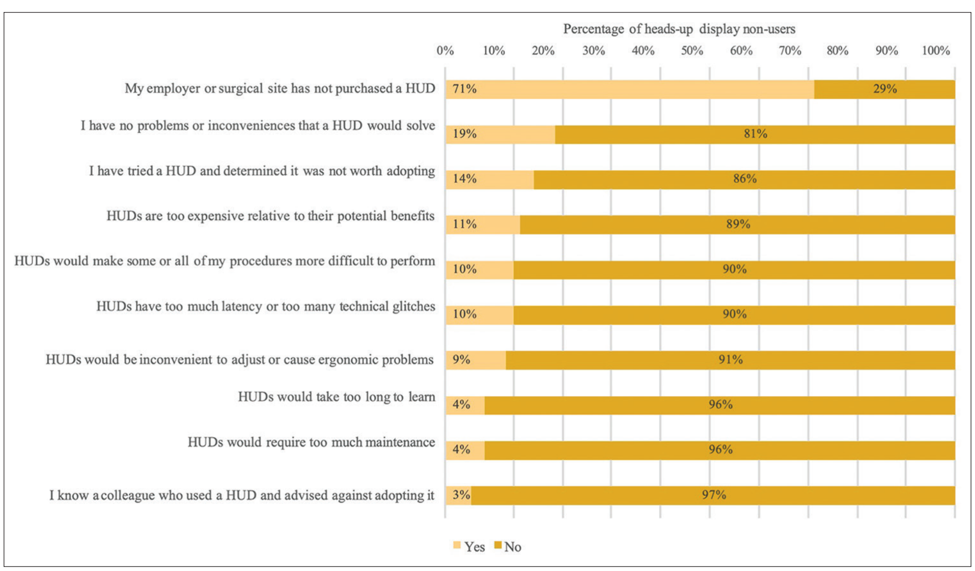

Figure 3: Reasons for not utilizing heads-up display

surgeons more likely to try HUD. Individuals with high volume practice at baseline may be more motivated to seek ergonomic surgical alternatives given the cumulative physical demands.

Demographically, the lack of female surgeons who use HUD may be a product of factors such as surgical volume disparities, income disparities, and increased gender-based career obstacles that could impede technology access.[20-22] Previous surveys have found that female ophthalmologists suffer more back, neck, and upper extremity pain compared to males.[4,23] Therefore, women in ophthalmology may face a double jeopardy, being in need of the possible MSK benefits of HUD more despite having comparably less HUD exposure. In terms of age, Bin Helayel *et al*. found that surgeons with 11–20 years of experience were significantly more likely to adopt HUD, whereas our study elucidated less than a 6-month difference in experience between users and nonusers.[9] The contrast may be attributable to location-specific features of the samples. Our study was limited to the U.S. ophthalmologists, whereas their authors were based in Saudi Arabia, with the scope of their respondent geography unspecified. Practice structures in the U.S. may afford ophthalmologists comparatively limited control over obtaining the technology even if certain age cohorts would be more willing to try it. Our finding of 71.4% of nonusers citing lack of HUD access as an obstacle supports such rationale. Separately, the lack of age difference may also be interpreted as a strength of our study, as it supports the notion that the observed difference in workload was not a product of age-related productivity differences between groups.

In terms of the challenges, there were difficulties with viewing angles and OR setup. The heft of current HUD systems combined with a fixed screen may contribute to issues, such by necessitating the surgeon to look around the scope for an optimal view. Similarly, the learning curve required to adapt an OR to HUD, with factors ranging from training staff to accommodating for left and right eye differences, impede adoption.[24] Nonusers shared sentiments regarding lack of access, lack of need, cost-effectiveness, and ergonomic and latency concerns. Only 13.1% of ophthalmologists in the current sample added new equipment for MSK symptoms, likely reflecting those barriers to entry. Simplification into more compact and flexible HUD designs such as with screens that swivel easily or that deliver consistent depth-of-field at off-angles may therefore enhance HUD implementation. Alternatively, use of head-mounted systems such as the Avegant Glyph retinal projection system (Avegant Corp, Belmont, CA, USA) may reduce the viewing angles concern because the image moves with the head rather than staying on a fixed monitor.[25] The coccydynia outside the OR noted by a single patient in the current study may be linked to the more reclined posture of HUD, which can lead to greater tailbone compression.[26] However, surgeons in other studies have generally found that seating angle to be more comfortable over time.[11,16]

The major disadvantages of this study are its small sample size and cross-sectional approach, which limit statistical power and causative inferences. The small sample size likely contributed to the large standard deviations observed for continuous variables as well as the lack of statistical significance when comparing total surgical cases. For example, the wide standard deviation of 47 months pertaining to length of HUD experience among users limits claims regarding effectiveness within that respondent group. Further, we did not collect information on the surgical case numbers and working hours of surgeons before they adopted HUD, so we cannot definitively assert that HUD use truly increased either metric. Given that retinal surgeons were the most likely to use HUD in our sample and that HUD has been most studied in the context of retinal procedures, it is a disadvantage that retina specialists were the least well-represented of our respondents.[11] Another disadvantage to the study is that information was not collected regarding historical 3D-visualization systems that have since been removed from the U.S. market or are not sold in the U.S., such as the TrueVision 3D-visualization system.[27] For users who had experience with older 3D systems, it may have been valuable to explore how the ergonomic experience has changed. There were also aspects of HUD intraoperative performance that were not explored, including previously reported benefits such as decreased phototoxicity, better depth of field, and educational value.[9,28]

Overall, the data from this cross-sectional survey speak to the potential utility of HUDs for relieving ophthalmologists' MSK symptoms. HUD surgeons reported greater working time than nonusers, but there were no significant differences in wellness measures. Most HUD users found that the technology helped reduce pain both inside and outside the OR and decrease fatigue compared to traditional analog oculars. Over two-thirds would recommend the technology to fellow ophthalmologists. However, there are ergonomic areas where the technology could improve, particularly with regard to viewing angles and setup in the operating suite. Other obstacles to adoption include lack of access, lack of perceived benefit, and concerns regarding latency. There may also be a gender disparity in use. Further, prospective studies that utilize greater sample sizes should be conducted to more definitively evaluate the risks and benefits of HUD systems.

Acknowledgement

The authors would like to thank all of the ophthalmologists who generously took the time to complete our survey.

Financial support and sponsorship

This study was supported in part by an investigator-initiated trial grant from the Alcon Research Institute (Fort Worth, TX, USA).

Conflicts of interest

There are no conflicts of interest.

References

1. Cruz OA, Pole CJ, Thomas SM. Burnout in chairs of academic departments of ophthalmology. Ophthalmology 2007;114:2350-5.

2. Viviers S, Lachance L, Maranda MF, M rand C. Burnout, psychological distress, and overwork: The case of Quebec's ophthalmologists. Can J Ophthalmol 2008;43:535-46.
3. Kitzmann AS, Fethke NB, Baratz KH, Zimmerman MB, Hackbarth DJ, Gehrs KM. A survey study of musculoskeletal disorders among eye care physicians compared with family medicine physicians. Ophthalmology 2012;119:213-20.
4. Dhimitri KC, McGwin G Jr., McNeal SF, Lee P, Morse PA, Patterson M, *et al.* Symptoms of musculoskeletal disorders in ophthalmologists. Am J Ophthalmol 2005;139:179-81.
5. Hyer JN, Lee RM, Chowdhury HR, Smith HB, Dhital A, Khandwala M. National survey of back & neck pain amongst consultant ophthalmologists in the United Kingdom. Int Ophthalmol 2015;35:769-75.
6. Al-Marwani Al-Juhani M, Khandekar R, Al-Harby M, Al-Hassan A, Edward DP. Neck and upper back pain among eye care professionals. Occup Med (Lond) 2015;65:753-7.
7. Diaconita V, Uhlman K, Mao A, Mather R. Survey of occupational musculoskeletale professionals. ophthalmologists in the Un Can J Ophthalmol 2019;54:314-22.
8. Tan NE, Wortz BT, Rosenberg ED, Radcliffe NM, Gupta PK. Digital survey assessment of factors associated with musculoskeletal complaints among US ophthalmologists. Clin Ophthalmol 2021;15:4865-74.
9. Bin Helayel H, Al-Mazidi S, AlAkeely A. Can the three-dimensional heads-up display improve ergonomics, surgical performance, and ophthalmology training compared to conventional microscopy? Clin Ophthalmol 2021;15:679-86.
10. Weinstock RJ, Ainslie-Garcia MH, Ferko NC, Qadeer RA, Morris LP, Cheng H, *et al.* Comparative assessment of ergonomic experience with heads-up display and conventional surgical microscope in the operating room. Clin Ophthalmol 2021;15:347-56.
11. Moura-Coelho N, Henriques J, Nascimento J, Dutra-Medeiros M. Three-dimensional display systems in ophthalmic surgery -A review. Eur Ophthalmic Rev. 2019;13:31-6.
12. Zhang Z, Wang L, Wei Y, Fang D, Fan S, Zhang S. The preliminary experiences with three-dimensional heads-up display viewing system for vitreoretinal surgery under various status. Curr Eye Res 2019;44:102-9.
13. Cruz DL, Ayres EW, Spiegel MA, Day LM, Hart RA, Ames CP, *et al.* Validation of the recently developed total disability index: A single measure of disability in neck and back pain patients. J Neurosurg Spine 2019;32:533-41.
14. Romano MR, Cennamo G, Comune C, Cennamo M, Ferrara M, Rombetto L, *et al.* Evaluation of 3D heads-up vitrectomy: Outcomes of psychometric skills testing and surgeon satisfaction. Eye (Lond) 2018;32:1093-8.
15. Skinner CC, Riemann CD. "Heads up" digitally assisted surgical viewing for retinal detachment repair in a patient with severe kyphosis. Retin Cases Brief Rep 2018;12:257-9.
16. Eckardt C, Paulo EB. Heads-up surgery for vitreoretinal procedures: An experimental and clinical study. Retina 2016;36:137-47.
17. Kelkar JA, Kelkar AS, Bolisetty M. Initial experience with three-dimensional heads-up display system for cataract surgery nt with severe kyphosi Indian J Ophthalmol 2021;69:2304-9.
18. Kumar A, Hasan N, Kakkar P, Mutha V, Karthikeya R, Sundar D, *et al.* Comparison of clinical outcomes between "heads-up" 3D viewing system and conventional microscope in macular hole surgeries: A pilot study. Indian J Ophthalmol 2018;66:1816-9.
19. Weinstock RJ, Diakonis VF, Schwartz AJ, Weinstock AJ. Heads-up cataract surgery: Complication rates, surgical duration, and comparison with traditional microscopes. J Refract Surg 2019;35:318-22.
20. McAlister C, Jin YP, Braga-Mele R, DesMarchais BF, Buys YM. Comparison of lifestyle and practice patterns between male and female Canadian ophthalmologists. Can J Ophthalmol 2014;49:287-90.
21. Gong D, Winn BJ, Beal CJ, Blomquist PH, Chen RW, Culican SM, *et al.* Gender differences in case volume among ophthalmology residents. JAMA Ophthalmol 2019;137:1015-20.
22. Jia JS, Lazzaro A, Lidder AK, Elgin C, Alcantara-Castillo J, Gedde SJ, *et al.* Gender compensation gap for ophthalmologists in the first year of clinical practice. Ophthalmology 2021;128:971-80.
23. Venkatesh R, Kumar S. Back pain in ophthalmology: National survey of Indian ophthalmologists. Indian J Ophthalmol 2017;65:678-82.
24. Kaur M, Titiyal JS. Three-dimensional heads up display in anterior segment surgeries gists.cal practice.almologists.l microscop Indian J Ophthalmol 2020;68:2338-40.
25. Korot E, Thanos A, Todorich B, Rao P, Stem MS, Williams GA. Use of the avegant glyph head-mounted virtual retinal projection display to perform vitreoretinal surgery. J VitreoRetinal Dis 2018;2:22-5.
26. Nathan ST, Fisher BE, Roberts CS. Coccydynia: A review of pathoanatomy, aetiology, treatment and outcome. J Bone Joint Surg Br 2010;92:1622-7.
27. Riemann CD. Machine vision and vitrectomy: three-dimensional high definition (3DHD) video for surgical visualization in vitreoretinal surgery. Stereoscopic Displays and Applications 2011;7863:187-94.
28. Rosenberg ED, Nuzbrokh Y, Sippel KC. Efficacy of 3D digital visualization in minimizing coaxial illumination and phototoxic potential in cataract surgery: Pilot study. J Cataract Refract Surg 2021;47:291-6.