

How Can We Better Inform Patients of the Importance of Contact Lens Compliance?: Current Perspectives

Jennifer Swingle Fogt , Madison Roth , Hope Patterson Gardner 

Ohio State University College of Optometry, Columbus, OH, USA

Correspondence: Jennifer Swingle Fogt, The Ohio State University College of Optometry, 338 West 10th Avenue, Columbus, OH, 43210-1280, USA, Tel +1 614-292-0882, Email Fogt.78@osu.edu

Abstract: Compliance with contact lens care is important for successful contact lens wear and for minimizing the risk of complications related to lens wear. There are many components of overall lens care guidelines that may potentially be disregarded, forgotten, or misunderstood. Literature has reported copious data on rates of poor compliance for separate lens care recommendations. Knowing the areas of contact lens care where lens wearers perform poorly is helpful when creating strategies for improving patient education. As science evolves and new best-practices are determined, eye care providers must be engaged in educating new lens wearers and reeducating existing wearers. It is vital to make wearers mindful of proper lens care and why proper lens care should be important to them. Various educational strategies can help practitioners to communicate with their patients more effectively. The purpose of this narrative review is to discuss studies of noncompliance with contact lens wear; consequences of these noncompliant behaviors; and studies of lens care education which were found with a literature search. The resulting discussion also includes strategies to improve compliance with patient contact lens wear.

Keywords: contact lenses, compliance, education, lens care

Introduction

Poor compliance with contact lens wear has long been known as a factor in contact lens complications.¹⁻⁴ Contact lenses and contact lens solutions are medical devices regulated by the Food and Drug Administration in the United States of America and by other government bodies throughout the world.⁵ Packaging of drugs and devices requires inserts with information for proper use of these products, and various health and eye care professional organizations around the world have published guidelines for safe contact lens care.⁶⁻¹⁰ Additionally, eye care practitioners have a role in ensuring new and existing lens wearers are aware of proper contact lens care practices in order to minimize risks associated with lens wear. Despite the availability of this information and the education provided to patients, non-compliance with contact lens wear persists, and numerous studies have explored the behavior of contact lens wearers and the implications of non-compliance on ocular health. While all types of contact lenses require proper hygiene, different contact lenses require different care regimens and replacement schedules and may have differing consequences if wearers are not compliant with these instructions. The following manuscript is a narrative review of articles published on contact lens compliance for different modalities of lenses. References were found by searching PubMed for “contact lens compliance” and “patient education techniques contact lenses” The initial search was completed on April 26, 2024, and included 464 articles. Articles that were specific to contact lens compliance and education regarding contact lens compliance were included in this review. Additional articles were found in the references of these articles. This exploration of contact lens wear compliance and non-compliance delves into the elements that play a role in proper contact lens wear and complications that arise as a result of non-compliance with these elements of care. Strategies for improving compliance with contact lens wear are also presented based upon research in this area.

Universal Elements of Proper Contact Lens Care

Hand Hygiene

Proper contact lens care begins with hand washing. Hand hygiene is a compliance issue that impacts every contact lens wearer, regardless of lens design or style of wear. The COVID-19 pandemic highlighted the importance of handwashing, and numerous health organizations, including the World Health Organization (WHO) and United States Center for Disease Control (CDC) promote alcohol-based hand sanitizer and handwashing with soap.^{11–13} For contact lens wearers, however, hand washing with soap is preferable since hand sanitizers contain alcohol that can contaminate lenses.^{14,15} Hands should be washed with soap and running water for at least 20 seconds, followed by rinsing well and drying thoroughly.¹⁶ Water temperature does not affect the effectiveness, and hot water should be avoided, as it can be more irritating to skin.^{12,17,18}

Overall compliance with hand washing before lens handling has varied widely, with one study finding only 16% of study participants reported “always” or “frequently” washing hands before lens use;¹⁹ three studies reporting 39.2%, 40% and 48% compliance with hand washing,^{20–22} and fifteen other studies showing compliance from 67.6% to 100% of study participants.^{23–37} Several studies have rates of participants who reporting rarely or never washing hands before lens handling, with three studies finding rates less than 5%,^{24,35,36} and one study reporting a rate of an alarming 63.3%.¹⁹ Table 1 presents a summary of studies that have reported on general hand washing habits related to contact lens wear.

Table 1 General Handwashing Compliance Assessment Research Summary

Lead Author	Publication Year	N (Subjects)	Population (mean age)	Country ^a	Hand Hygiene Criteria	Compliance Rate
Albasheer ²⁴	2024	391	Adults (NA)	SA	“Do you clean your hands before wearing or removing contact lenses”.	85.5%
Bakkar ³⁰	2020	210	University students 18–39 (22)	JO	“Hand-washing before lens use”	95.7%
Barisic Kutija ²⁹	2022	50	Ages 12–65 (36)	HR	“Hand washing before lens system hygiene”	100%
Bui ²⁶	2010	162	Ages 13–75 (39)	US	“Washing hands before handling lenses”	93.0%
Gyawali ²²	2014	107	Ages 16–42 (21)	MV	“Hand washing before handling lenses”	39.2%
Khan ³¹	2013	500	Healthcare workers (NA)	PK	“Hand washing before contact lens use”	82.0%
Khoza ³²	2020	247	Ages 18–30 (24)	ZA	“Effective and thorough method of cleaning their hands prior to C/L handling”	71.3%
Mingo-Botin ³⁵	2020	1264	Purchase CL online (41)	ES	“Hand washing ‘often/always’”	91.4%
Morgan ²⁰	2011	4021	Ages 21–60 (37)	AU, CA, CN, DE, ES, FR, IN, IT, JP, KR, PL, RU, GB, US	“Hands washed before application and removal with soap, hand sanitizer, or wet wipe”	“about 40%”

(Continued)

Table I (Continued).

Lead Author	Publication Year	N (Subjects)	Population (mean age)	Country ^a	Hand Hygiene Criteria	Compliance Rate
Naaman ¹⁹	2022	150	Health-care students (22)	SA	“Washing hands before lens use”	16.0%
Ocansey ²⁸	2019	42	Ages 15–68 (29)	GH	“Do you wash your hands thoroughly before wearing your contact lens?”	97.6%
Ramamoorthy ²¹	2014	100	Ages 18–39 (25)	US	“Washed hands with soap, antiseptic liquid, or wipes before inserting or removing lenses from the eyes”	48.0%
Robertson ³³	2011	281	Ages 18–75 (36)	US	“Hand washing before handling lenses”	51%
Sapkota ²⁷	2015	78	MDs and age-matched normal subjects (32)	NP	“Washing hands with soap and clean water before handling lenses”	94.9%
Supiyaphun ³⁶	2021	336	University students (19)	TH	“Wash hands before inserting or removing CL ‘every time’”	83.30%
Taslipinar Uzel ²⁵	2018	121	Ophthalmologists (33)/ health-care workers (29)/ normal subjects (29)	TR	“Washing hands with clean water and soap before handling lens”	92.3–100%
Wu ³⁷	2010	111	Ages 15–64 (34)	AU	“Did you wash your hands before you handled your lenses the last time”	89%
Zengin ²³	2021	929	University students 18–24 (22)	TR	“I wash my hands before wearing/removing CLs”.	85.4%
Zhu ³⁴	2018	297	University students 17–25 (NA)	CN	“Wash hands before handling”	86.2%

Notes: ^aCountry codes: AU Australia, CA Canada, CN China, DE Germany, ES Spain, FR France, GB United Kingdom, GH Ghana, HR Croatia, IE Ireland, IN India, IT Italy, JO Jordan, JP Japan, KR South Korea, MV Maldives, MX Mexico, NP Nepal, PL Poland, PS Palestine, RU Russia, SA Saudi Arabia, SD Sudan, TH Thailand, TR Turkey, US United States, ZA South Africa. (NA=not available)

Additionally, studies have shown that hand washing is more likely before lens application than before lens removal.^{38–48} Studies that specifically asked lens wearers about washing hands with soap before lens application/removal found disparities in rates of compliance of 56%/51%; 67%/59%; and 70%/50%.^{44–46} Studies have reported rates from 5.5% to 31% participants reporting they “do not always” or “never” wash hands with soap before handling lenses.^{39,41,46,49–51} Table 2 presents a summary of studies related to compliance with hand washing that specifically surveyed participants on timing of hand washing and how they define “washing” their hands before handling lenses.

Lack of proper handwashing before handling contact lenses is a known risk factor for microbial keratitis and non-ulcerative keratitis.^{3,46} A study by Morgan found a 4.5x greater risk of contact lens associated infections in study participants who did not wash hands.²⁰ A study by Lim found a 13x increased risk of microbial keratitis infection in study participants who did not wash hands before handling their lenses.⁵³ Consequences of handwashing non-compliance is not limited to reusable lenses. Handwashing before lens handling, even when wearing single-use lenses, decreases the risk of moderate to severe microbial keratitis by 50%.⁵⁴

Table 2 Handwashing Survey Results for Specific Questions About Handwashing Related to Contact Lens Wear and Care

Lead Author	Year	N (Subjects)	Population (mean age)	Country ^a	Hand Hygiene Criteria	Compliance Rate
Beshtawi ³⁸	2022	133	University students 18–45 (22)	PS	“Hands washing with soap prior to lens insertion”	92.5%
					“Hand washing with soap prior to lens removal”	65.4%
Bian ³⁹	2021	238	Ortho-k ages 7–25 (11)	CN	“Adequate hand washing”	78.2%
					“Washing hands before wearing lenses”	97.9%
					“Washing hands before removing lenses”	88.7%
					“Washing hands with soap”	86.1%
Cardona ⁴⁰	2021	145	Wearers early during COVID-19 (28)	ES	“Always wash hands before lens insertion”	62%
					“Always wash hands before lens removal”	54%
					“Always clean with soap and water before lens manipulation”	39%
					Handwashing does “not always use soap”	31%
Çavdarlı ⁴⁹	2021	109	Ages 12–60 (NA)	TR	“Hand washing before handling the CLs”	94.5% ^b
					“Hand washing with soap”	94.4%
					“Hand drying after hand washing”	88.8%
Chalmers ⁴¹	2016	968	Ages 20–76 (44, 45)	US	“Wash hands before lens insertion”	68.6% ^c
					“Use soap with lens insertion”	63.5% ^c
					“Wash hands before lens removal”	47.3% ^c
					“Use soap w/removal”	49.5% ^c
Dumbleton ⁴²	2013	2147	Ages 16–81 (36)	US	“Frequency of hand washing before lens insertion”	95% ^d
					“Frequency of hand washing before lens removal”	91% ^d
Dumbleton ⁵¹	2013	100	Younger group (20), older group (49)	CA	“Wash hands–insertion”	95% ^e
					“Wash hands–removal”	81% ^e
					“Hands washed with soap and water”	86% ^e
Gammoh ⁴³	2021	442	Ages 18–45 (25)	SD	“Hands washing before inserting CL”	92.1%
					“Hands washing before removal of CL”	79.9%
Gammoh ⁴⁸	2023	834	Ages 18–55 (26)	JO	“Hands washing before inserting CL”	81.4%

(Continued)

Table 2 (Continued).

Lead Author	Year	N (Subjects)	Population (mean age)	Country ^a	Hand Hygiene Criteria	Compliance Rate
Garcia-Ayuso ⁴⁴	2022	266	Ages 18–49 (22)	ES	“Always wash hands with soap and water before CL insertion”	67%
					“Always wash hands with soap & water before CL removal”	59%
Hickson-Curran ⁴⁵	2011	645	Ages 12–39 (26, 27)	US	“Wash hands with soap always in the morning”	56%
					“Wash hands with soap always in the evening”	51%
Ibrahim ⁵²	2018	217	Medical students (NA)	SA	“Washing hands before putting on lenses”	71.9%
					“Using soap when washing hands before using lenses”	57.1%
					“Drying hands before wearing contact lenses”	60.8%
Udomwech ⁴⁶	2022	20	Ages 17–58 (35)	TH	“Hand wash with soap before putting in CLs”	70%
					“Hand wash with soap before CLs removal”	50%
Vianya-Estopa ⁴⁷	2021	247	Wearers early during COVID-19 ages 19–63 (34)	GB, IE	“Following the recommended 20-second rule most times/every time”	87%
					“Wash hands with soap and water”	96%
					“Handwashing before contact lens insertion”	94% ^e
					“Handwashing before contact lens removal”	88% ^e

Notes: ^aCountry codes: AU Australia, CA Canada, CN China, DE Germany, ES Spain, FR France, GB United Kingdom, GH Ghana, HR Croatia, IE Ireland, IN India, IT Italy, JO Jordan, JP Japan, KR South Korea, MV Maldives, MX Mexico, NP Nepal, PL Poland, PS Palestine, RU Russia, SA Saudi Arabia, SD Sudan, TH Thailand, TR Turkey, US United States, ZA South Africa. ^bCompliance rate compiled based upon survey responses “Always” and “Often”. ^cCompliance rate for survey responses of “Always”. ^dCompliance rate compiled based upon survey responses “Every time” and “Most of the time”. ^eCompliance rate compiled based upon survey responses “Every time” and “Most times”. (NA=not available)

Exposure to Water

FDA guidelines instruct patients to avoid exposing contact lenses to any water.⁹ In 2019, a task force convened to investigate contact lens-related microbial keratitis and advised that patients “eliminate all tap water” in lens care.⁵⁵ Studies have also reported that 11.2% to 52.4% of patients fail to completely dry hands which exposes lenses to tap water.^{39,49,50,52,56} Additional water exposure can occur when patients clean storage cases with tap water, which has been reported at rates of 25.6% to 72%.^{1,29,40,41,45,49,51,57} Using water to clean soft lenses has been reported by up to 31% of wearers.^{19,26,30,35,36,38,41,43,46,48,56,58} This behavior has been reported even more frequently in rigid lens wearers, at rates as high as 91%.^{26,29,58}

Water exposure occurs with lens wear during bathing or showering. Studies have reported contact lens wear during showering at rates from 12.8% to 86.5%.^{29,35,38,43,49,56,59–61} Swimming and water sports during lens wear are known areas of contact lens non-compliance, occurring in both pools and natural bodies of water. Although wearing goggles or

using daily disposable lenses might lessen associated risks,⁶² many patients do neither.^{22,37,56} Reports of swimming while wearing lenses has varied from 4.1% to 68.1%.^{22,23,26,35,37,38,43,47,56,61}

Interestingly, patients with medical experience who should be fully aware of the hazards of exposing contact lenses to water are reported to be non-compliant with their own lens wear. A 2017 study surveyed ophthalmologists, healthcare workers, and age-matched laypeople, and found that 52%, 50% and 61.6% exposed their own contact lenses to water, respectively.²⁵ Sapkota noted similar water exposure between physicians (94.9%) and people without a medical background (96.2%).⁶³

Water exposure can adversely affect contact lens wearers due to its common microbial contaminants. One study found that showering while wearing lenses daily increased the risk of microbial keratitis 7x compared to compliant contact lens wearers.⁶⁴ Acanthamoeba are opportunistic, free-living protozoa that exist in water, including household tap water, bodies of fresh and salt water, spas, tap water, and even distilled water.^{65,66} These opportunistic microbes can cause infections in all humans but are more likely to infect contact lens wearers and people who are immunocompromised.⁶⁵ Mechanisms of infection of the eye by acanthamoeba generally starts at the epithelial cells, and can infiltrate the cell level by an abrasion or cells which have become damaged by other mechanisms, like hypoxia induced by sleeping in lenses.⁶⁷ Infection of the eye by acanthamoeba is painful and visually devastating, often resulting in scarring and blindness.⁶⁸ Due to the severity of these infections, prevention of water exposure to eyes, contact lenses, and contact lens products is important.

Additionally, water can harbor bacteria, including *Pseudomonas aeruginosa*, another common cause of microbial keratitis.⁵⁶ Furthermore, the endotoxins produced by gram-negative bacteria are believed to cause corneal infiltrative events.⁶⁹ A study in Japan found that a major cause of contact lens associated infections that caused severe vision loss, perforation of the cornea, or required surgical intervention were *Pseudomonas aeruginosa* and *Acanthamoeba*.⁷⁰

Lens Care Products

Case Replacement and Hygiene

Practitioners worldwide recognize the importance of case hygiene and replacement in wearers of reusable contact lenses. The British Contact Lens Association advises case replacement at least monthly, while several US and an Australian organization advise replacing lenses at least every 3 months.^{6–8,10,71} Manufacturers including a case with a bottle of solution make using a new case straightforward, although studies have found only 36.4% and 42.1% of study participants reported replacing their case replacement upon opening a new bottle of solution.^{40,49}

Because recommended replacement schedules for contact lens cases vary among these international organizations, it is not surprising that studies have found differences in replacement schedules by patients. Two studies asked lens wearers if they replace their lens cases monthly, which likely reflects the replacement recommendations of their geographic area, finding rates of >50% and 90.9% compliance.^{38,47} Lower rates of monthly case replacement were found in a majority of studies, ranging from 9% to 48.9%.^{1,32,37,40,42,43,45,48–51,60,72} Percentages are higher in studies which asked participants if they replaced contact lens cases within 1 to 3 months of first use, with reported rates ranging from 24.5% to 90.2%.^{1,19,29,30,36,40,42–45,48,49,51,59–61,72,73} Studies have found rates from 2.8% to 20% of people surveyed reporting that they never replace their contact lens case.^{1,40,42,45,49–51,72,73} Worse still are patients who neither clean nor replace their cases, as 9.1% of subjects reported in a study by Cardona.⁴⁰

Replacement is important because used contact lens cases have been found to harbor microbes known to cause ocular infection, including acanthamoeba, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and fungi.^{2,74,75} A study by Kuzman examined contamination of contact lens cases and found that the insides of the cases which were used less than 3 months did not find bacteria when cultured.⁶¹ Although other non-compliance behaviors beyond age of a case can play a role in case contamination, completely replacing a case assures that no previous contaminants can persist.⁶¹

Between replacements of cases, microbes that grow on the case surface can develop into a biofilm that enhances survival of unwanted pathogens.⁷⁶ Rinsing cases with disinfecting solution might offer slight antimicrobial benefit, but it is not effective in biofilm removal; removal of this biofilm is more effective with rubbing, either digitally or with a tissue, than rinsing alone.⁷⁷ Rubbing also helps to remove bacterial endotoxins. Drying the case after rubbing and disinfection is

an important step. Rubbing the case dry with a tissue helps to lessen the adherence of *Acanthamoeba*.⁷⁸ Leaving the case open to completely air-dry is ideal, specifically with the wells face down to allow faster drying and to minimize contamination by airborne microbes.⁷⁹ This is particularly important if lens handling occurs in the bathroom, as this environment is often humid and exposes cases to the aerosol spread of microorganisms from toilets flushing.^{79–81} Cases should be thoroughly cleaned using these steps each time lenses are worn, but compliance with this task is often quite poor. Daily cleaning of a case has been reported at rates from 14.3% to 57.9%.^{24,30,38,40,44–46,48} While some studies have found one third or less study participants reported storing their lens cases upside down with caps removed to dry during lens wear,^{42,47,51} other studies report higher rates ranging from 40% to 85.9%.^{25,27,45} Khoza found that 92% of subjects properly use solution, rubbing, and air-drying in case hygiene.³²

Various studies have discussed the role of bacterial biofilms on contact lenses and lens cases in relation to microbial keratitis.^{82–84} Tilia reported contamination of 79% of all cases examined in a study when cases were collected after 1 month of use; significantly more cases were contaminated with gram negative bacteria among participants who reported exposure to tap water compared to participants who avoided water when cleaning lenses and cases.² A study of patients diagnosed with microbial keratitis found that the biofilm of contact lens cases showed greater bacterial contamination than the lenses themselves.⁸³ Of course, the use of cases necessitates the use of contact lens solution, which, if used incorrectly, can introduce additional sources of case contamination. These non-compliant factors and resulting complications are discussed in more detail in the following sections.

Contact Lens Solution Use

Studies of contact lens behaviors have found several ways in which contact lens solutions can be improperly used. Failure to rub and rinse lenses has been reported at rates ranging from 5% to 80% of participants in various contact lens studies.^{19–21,25,27,30,43,46–48,57,60,85} Adding additional solution to a case containing previously used solution, known as “topping off” instead of using new solution in a case each time lenses are stored has been found to varying degrees from 4% to <40%.^{19–21,22,26,28,29,37–40,43,46,48}

Consequences of improper contact lens solution use can cause devastating visual outcomes resulting from microbial keratitis. When “topping off” without cleaning and rubbing the case, any biofilm present from previous use remains intact while the previously used solution is mildly diluted with the newly added solution. A study found that risk factors for *acanthamoeba* keratitis among rigid gas permeable lens wearers included topping off solution, storing lenses in tap water, and sleeping in lenses.⁸⁶ A 2007 publication on an outbreak of *acanthamoeba* keratitis in Chicago found that “topping off” solution was a factor that was associated with these infections.⁶⁸ This outbreak was then investigated on a national level with similar findings, including “topping off” as one of the matched factors found among patients with *acanthamoeba*.⁸⁷ Both of these studies also identified use of one particular contact lens solution, which has since been removed from the market, as a risk factor.^{68,87} A large outbreak of fungal keratitis also occurred worldwide and was associated with a different multipurpose solution that was later pulled from the market.⁸⁸ In both of the solution outbreaks mentioned during this time, no contaminants were found in bottles of solution.⁸⁸ These outbreaks brought to light the variability of contact lens solutions in killing microbes and brought attention to the importance of rinsing and rubbing lenses to prevent contamination or contribution of microbes outside of a laboratory.⁸⁹ A study by Brown explored the time period after the two outbreaks mentioned above found that poor contact lens hygiene and “topping off” remain as causes for growth of *Acanthamoeba*.⁹⁰

Due to the increased risks shown when lens solutions and cases are added to soft lens wear, it is in the best interest of patients to switch to single-use lenses when possible, as they have lower rates of microbial and sterile keratitis compared to reusable lenses.⁹¹ Lens care solutions and cases introduce a risk to contact lenses wear, particularly if patients are non-compliant with lens hygiene.⁹¹

Contact Lens Replacement

Because contact lenses are a medical device, labelling of lenses includes a replacement schedule which has been tested in studies conducted during the FDA approval process. Despite the instructions for replacement, compliance with

manufacturer recommended replacement frequency can vary widely among users, with reports ranging from 25% to 87%.^{19–22,30,32,36,41,46,48,61,73}

Studies of compliance have found that wearers are more compliant with some replacement modalities than others. The greatest compliance with prescribed lens replacement is found with single-use, or daily disposable lenses. Compliance with daily replacement of single-use lenses has been reported at rates of 49.3% to 95%.^{35,42,50,51,72,73,92–94} Compliance with correct replacement of monthly reusable soft lenses is lower, with reported at rates of 30.9% to 78%.^{1,35,42,50,51,72,73,94,95} Compliance with the replacement of 2-week lenses is worse yet, with rates of 18% to 59%.^{1,35,42,45,51,72,73,94,95}

This issue can be further complicated by practitioners who prescribe replacement at intervals other than what is advised by the manufacturer, which has been reported most for 2-week lenses and least for daily disposables.^{1,72} Rueff noted that 23.2% of participants reported a replacement schedule that differed from manufacturer guidelines; this equated to 46.7% of 2-week lens wearers, 5.9% of monthly lens wearers, and no single-use lens wearers.⁷³ Dumbleton reported altered replacement schedules prescribed for those lens modalities respectively of 35%, 9.6%, and 5.9% in Canada and 18.7%, 18.3%, and 4.0% in the United States.⁷² In another investigation Dumbleton noted Canadian practitioners changing the replacement frequency for 2-week lenses and monthly lenses in 50.0% and 9.4% of patients respectively.¹

Internationally, rigid gas permeable (RGP) contact lenses, including corneal, scleral and orthokeratology lenses, compose 15.3% of lens fittings.⁹⁶ Replacement of these lenses is more individualized, considering wearer characteristics, lens material, and eye care practitioner judgement. Lenses should be replaced frequently enough to avoid significant depositing, lens surface or edge damage, and alterations in oxygen permeability that would compromise eye health.⁹⁷ Rigid lenses deteriorate with age to differing degrees, with low Dk materials tending to have the longest lifespan. Jones evaluated low Dk (≤ 40), mid Dk (41–90), and high Dk (≥ 90) RGP lenses, finding that the mean lens life was 20 months, 16 months, and 9 months, respectively.⁹⁸

Given the more individualized prescribing of rigid lens replacement, few studies have evaluated patient compliance in this regard. Barisic-Kutija reported 96% compliance with RGP replacement when the replacement interval was considered to be 3 years.²⁹

Noncompliance with lens replacement schedules is more difficult to link to a specific consequence. A study by Dumbleton found that lens wearers who did not replace their lenses as recommended were more likely to be noncompliant in other lens care behaviors.¹ The same study found trends of more serious ocular complications occurring to those who did not follow replacement schedules compared to those who followed the schedule correctly. A study by Yeung also found more complications per eye - including giant papillae conjunctivitis, injection, corneal staining, infiltrates, and ulcers - in those who overwore their lenses by 3x the recommended replacement time compared to those who discarded lenses as recommended.⁹⁴

Sleeping in Lenses

Contact lenses for daily wear are considered a class II medical device by the FDA, while lenses approved for extended wear or continuous wear are class III devices due to the high risks involved when lenses are worn overnight.⁹⁹ Daily wear contact lens wearers are cautioned not to sleep in lenses. Even so, many wearers nap or sleep in lenses, with reported rates of 0.7% to 69% in various studies.^{1,19–23,25–30,32–35,38,41–44,46,48–52,57,61,73,92,}

Interestingly, the occurrence of nonprescribed overnight wear has been reported at similar rates among daily disposable, 2-week replacement, and monthly replacement soft lens wearers.⁷³ Of the 23.9% of subjects who reported overnight wear noncompliance, 15% wore a daily disposable lens. This was found to be true of 37% of daily disposable wearers in another study; 56% of those noncompliant subjects reported overnight wear of once a week or more.⁹² Table 3 summarizes the findings of the studies related to compliance with not sleeping while wearing lenses.

Wearing soft or rigid contact lenses overnight increases the risk of microbial keratitis in lens wearers.¹⁰⁰ Overnight wearers of soft hydrogel and silicone hydrogel lenses respectively have been found to occur in 20–25 of 10,000 lens wearers.¹⁰¹ This is a higher risk than the 1.9–2.2 in 10,000 incidence of microbial keratitis found in daily wear of soft lenses.¹⁰¹

Table 3 Summary of Study Results Related to Compliance with Not Sleeping While Wearing Contact Lenses

Lead Author	Publication Year	N (Subjects)	Population (Mean Age)	Contact Lenses ^a	Country ^b	Compliance Rate (NOT Sleeping in Lenses)
Bakkar ³⁰	2020	210	University students 18–39 (22)	S, R	JO	95.7%
Barisic Kutija ²⁹	2022	50	Ages 12–65 (36)	R	HR	100%
Beshtawi ³⁸	2022	133	University students 18–45 (22)	S	PS	97.0%
Bui ²⁶	2010	162	Ages 13–75 (39)	S, R	US	71.8%
Cardona ⁴⁰	2021	145	Wearers early during COVID-19 (28)	S, R	ES	84%
Çavdarlı ⁴⁹	2021	109	Ages 12–60 (NA)	S	TR	69.4%; Nap 43.5%
Chalmers ⁴¹	2016	968	Ages 20–76 (44–45)	S	US	74.6%; Nap 42.8% ^c
Dumbleton ¹	2011	501	Ages 17–75 (36)	S	CA	33%; Nap 49%
Dumbleton ⁵¹	2013	100	Younger group (20), older group (49)	S	CA	44%; Nap 53%
Dumbleton ⁴²	2013	2147	Ages 16–81 (36)	S	US	34%; Nap 65%
Gammoh ⁴³	2021	442	Ages 18–45 (25)	S, R	SD	99.3%
Gammoh ⁴⁸	2023	834	Ages 18–55 (26)	S, R	JO	95.3%
Garcia-Ayuso ⁴⁴	2022	266	Ages 18–49 (22)	S, R	ES	90.2%
Gyawali ²²	2014	107	Ages 16–42 (21)	S	MV	74.80%
Ibrahim ⁵²	2018	217	Medical students (NA)	S, R	SA	70.5%
Khoza ³²	2020	247	Ages 18–30 (24)	S, R	ZA	58.3%
Kuzman ⁶¹	2014	52	N/A (28)	S, R	HR	42.3%
Lutmer ⁹²	2022	100	Ages 18–33 (24)	S	US	63%
Mingo-Botin ³⁵	2020	1264	Purchasers of CL online (41)	S	ES	92.3%; Nap 61.2%
Morgan ²⁰	2011	4021	Ages 21–60 (37)	S, R	AU, CA, CN, DE, ES, FR, IN, IT, JP, KR, PL, RU, GB, US	52%
Naaman ¹⁹	2022	150	Health-care students (22)	S, R	SA	95.3%
Ocansey ²⁸	2019	42	Ages 15–68 (29)	S, R	GH	90.5%
Ramamoorthy ²¹	2014	100	Ages 18–39 (25)	S	US	47.0%
Ramos-Davila ⁵⁷	2024	287	Ages 14–78 (25)	S, R	MX	69%
Rueff ⁷³	2019	297	Ages 18–67 (34)	S	US	76.1%
Robertson ³³	2011	281	Ages 18–75 (36)	S, R	US	44%
Sapkota ²⁷	2015	78	MDs/age-matched normal subjects (32)	S	NP	94.9%/97.9%

(Continued)

Table 3 (Continued).

Lead Author	Publication Year	N (Subjects)	Population (Mean Age)	Contact Lenses ^a	Country ^b	Compliance Rate (NOT Sleeping in Lenses)
Supiyaphun ³⁶	2021	336	University students (19)	S	TH	70.5%
Taslipinar Uzel ²⁵	2018	121	Ophthalmologists (33)/ health-care workers (29)/ normal subjects (29)	S	TR	96%/81.8%/82.7%
Udomwech ⁴⁶	2022	20	Ages 17–58 (35)	S	TH	55%
Zengin ²³	2021	929	University students 18–24 (22)	S	TR	81.5%
Zhu ³⁴	2018	297	University students 17–25 (NA)	S, R	CN	87.8% ^d

Notes: ^aContact lenses of wearers reported: S Soft lenses, R Rigid lenses. ^bCountry codes: AU Australia, CA Canada, CN China, DE Germany, ES Spain, FR France, GB United Kingdom, GH Ghana, HR Croatia, IE Ireland, IN India, IT Italy, JO Jordan, JP Japan, KR South Korea, MV Maldives, MX Mexico, NP Nepal, PL Poland, PS Palestine, RU Russia, SA Saudi Arabia, SD Sudan, TH Thailand, TR Turkey, US United States, ZA South Africa. ^cCompliance rate compiled based upon survey responses of “never” and “infrequently”. ^dCompliance rate compiled based upon survey responses “never” and “seldom”. (NA=not available)

Orthokeratology requires overnight wear of lenses which is unavoidable. The overall incidence of microbial keratitis with orthokeratology is 7.7 per 10,000, which reaches a slightly higher rate of 13.9 per 10,000 when only considering children.¹⁰² No prospective studies have been able to capture an incidence of microbial keratitis in scleral lens wear for daily wear or overnight wear, although a retrospective study estimated a rate of 45 cases per 10,000 for daily wear.¹⁰³ Many scleral lens wearers require these lenses for correction of irregular corneas and/or ocular surface disease, and the benefits outweigh the risks, although all patients should be made aware of the risks and subsequent need for compliant lens wear. A small study with 4 subjects wearing scleral lenses overnight found increased swelling of the cornea due to hypoxia, but concluded that overnight wear with a scleral lens should not be ruled out if the benefit of overnight therapeutic wear, which is typically reserved for severe ocular surface disease, is greater than the hypoxic effect induced.¹⁰⁴

Other Lens Care Considerations

Use of Makeup and Beauty Products

Compliance with recommendations regarding beauty product use with contact lenses is less documented in the literature than other behaviors. Two studies reported compliance rates of 37.4% and 58.7% with applying makeup after lens insertion.^{32,49} No mention was found in the literature of compliance with other products, such as makeup removers and beauty creams. There is also a paucity of information on patients removing makeup after lens removal, using hypoallergenic products safe for lens wearers, avoiding oil-containing products near the eyes, avoiding mascara with fibers that can flake into eyes, and replacing cosmetics regularly.

It is important that eye care practitioners educate patients on cosmetic use, as studies have found that users of cosmetics like eyeliner and mascara have greater tear film instability and meibomian gland changes when compared to non-make up wearers.^{105,106} Eye care practitioners teaching proper makeup usage with contact lens wearers may be in competition with cosmetic companies who instruct wearers of eyeliner, to use waterproof products that will adhere to the “waterline” which is the terminology used to describe the area inside the eyelashes where the meibomian glands are present. Covering the meibomian glands is hypothesized to obstruct the glands, which could lead to structural changes or long-term dysfunction, leading to eventual evaporative dry eye.¹⁰⁷

Wearing Time

Specific hours of lens wear are not typically published in contact lens guidelines, although practitioners may recommend a lens wear schedule for patients. One report defined successful daily lens wear as 12 hours per day, 6 days a week for both soft and rigid gas permeable lenses.¹⁰⁸ Kuzman found that daily wear exceeding 12 hours was a positive predictor of microbial contamination of both the inside and rims of case wells, suggesting that 12 hours may be the “upper limit for safe contact lens wear”.⁶¹

Unfortunately, patients often continue to wear lenses after comfort has declined.⁷² Increased wear time has been associated with less compliant behavior in lens wearers. It has been linked to lower overall contact lens compliance, increased lens exposure to water, and more sleeping in lenses.^{25,27,29,30,35,36} Not surprisingly then, excessive wearing time can also result in increased likelihood of complications. Increases in hyperemia and bulbar and palpebral conjunctival inflammation over the course of the day are recognized signs that may be an immune response to contact lens intolerance.¹⁰⁹ A study by Papas replaced soft lenses after 10 hours of wear with a new lens and found that comfort was not improved with lens replacement, which implies that declining comfort over the day is best solved by removing lenses completely.¹¹⁰ Some guides for soft contact lens care suggest that lenses should be removed for the day when uncomfortable.⁶

Implications of wear time of wearers of rigid lens materials may exceed increasing discomfort over the day.¹⁰⁰ Wearers of scleral lenses often experience midday fogging, which necessitates lens removal, cleaning, refilling with non-preserved saline, and reapplication in order to see clearly.^{111–113} Because scleral lenses are often fit for therapeutic reasons, these wearers may not be able to shorten their wear time, as they require lenses in order to have functional vision. In these situations, wearers should report their lens wear experiences to their eye care practitioners to make sure that any blur or discomfort issues are not related to hypoxia.¹¹⁴

Predictability of Compliance

Investigators have tried to elucidate which patients are most likely to be compliant. This issue is confounded by contact lens regulations that vary across the globe, with some nations not requiring a prescription for lens purchases.⁹⁹ Rates of contact lens-related microbial keratitis are higher in markets without required prescriptions.⁹⁹ Contact lens wearers who do not complete annual contact lens follow-ups were found to have greater ocular complications than those who do not follow the prescribed annual visits.¹¹⁵ Asymptomatic contact lens wearers returning for an annual visit to renew their contact lens prescriptions were found to have numerous complications related to ocular health, contact lens related fit issues, and non-compliance in a large retrospective study at two large eye clinics.¹¹⁶ Studies comparing age and gender have found conflicting results.^{19–22,24–27,29,30,34,35,38–40,43,48,73,93,94} Numerous investigators have found compliance to lessen with greater years of contact lens wear. Two studies found that compliance was better in those wearing lenses less than 5 years or ≤ 5 years compared to those with a longer history of lens wear.^{35,57} Two studies have found that water exposure with contact lenses is statistically more likely in those with a longer history of lens wear.^{38,44} Dumbleton found that patients noncompliant with lens replacement had worn lenses longer than those who were compliant.¹ Conversely, several other studies found no link between years of lens wear and compliance.^{25,27,29,40,73}

The number of hours of lens wear each day might be a better indicator of the likelihood of compliance. Two studies found improved compliance with study participants who wear lenses <8 hours and <14 hours a day.^{29,35} Similarly, three other studies have likewise noted that poorer compliance is associated with longer wear times during a day.^{25,27,36} Poorer compliance has also been associated with wearing lenses more days each week. Supiyaphun noted less compliance if lenses are worn more than 5 days a week, and Morgan agreed that part-time wearers had fewer noncompliant behaviors even after accounting for their higher use of daily disposable lenses.^{20,36}

Discussion

There are many reasons for patient noncompliance with contact lens wear. Human behavior is imperfect. Enhancing compliance with proper lens wear is difficult if patients do not even recognize that a behavior is noncompliant. Studies show a discrepancy between a patient's perceived compliance with proper lens wear and that individual's actual

compliance. Bui found that 86% of subjects believed themselves compliant; in actuality, 32% of subjects had good compliance, which was defined as 90% or greater correct lens care behaviors.²⁶ Robertson et al found that 85% of subjects perceived they had compliant behavior, but less than 5% were assessed to have good compliance.³³ A study by Gyawali et al found that 90% of participants believed themselves to be “good” or “average” lens wearers, but high rates of non-compliant behaviors were also reported, leaving investigators questioning whether the participants were unaware of proper care, or if the poor behavior was due to personal negligence.²² The disconnect between wearer knowledge of proper lens wear practices and wearer behavior should be taken into consideration when determining how to improve lens wearer behavior. Although two studies reported finding no correlation between knowledge of proper lens care and wearer behavior,^{36,57} it has been reported that participants with increased frequency of sleeping in contact lenses, exposing lenses to water, and infrequent case replacement, were unaware of the risks of these behaviors.³⁵ Thirty percent of contact lens wearers in a 2003 survey felt inadequately prepared regarding lens care, indicating a potential lack of understanding and knowledge.¹¹⁷ In fact, it has been noted that 74% of noncompliant patients were completely unaware that their behavior practices were problematic.¹¹⁸ It appears that patients are unintentionally misusing their lenses due to factors such as misunderstanding, forgetfulness, poor explanations by the provider, and inadequate information. This is of no surprise considering previous reports document patients forget as much as 50% of presented medical education within minutes of leaving a medical visit.¹¹⁹ The retention of medical recommendations is believed to depend on the doctor–patient relationship and repetition, and any measures that improve these two factors should help in improving compliance.¹¹⁹ Additionally, shorter periods of instruction have been shown to improve the percentage of material remembered by patients.¹²⁰

As our understanding of risks expands, it is necessary to change guidelines to address new information. However, patients who have not experienced consequences from their past behaviors may be resistant to change. One example of this is the change in recommendations with water usage and rigid contact lens care over the past three decades. Rigid lens products initially included instructions to use water to rinse cleaner from the lenses, and these labels persisted with some products even after the risks of doing so were well established.¹²¹ Although tap water is better at rinsing cleaners from a rigid lens surface than saline, the associated risks preclude use of water.¹²² The longstanding use of water to care for rigid lenses may be a difficult compliance issue to overcome. Steele noted 57.4% of practitioners from across the globe using water in rigid lens care in office, although only 32.7% did so in front of patients.¹²³ The survey participants who rinsed with tap water assigned less risk to water-associated behaviors than participants who did not rinse with water. This discrepancy in perceived risk is also more common among patients who use water during lens care.⁵⁸ In the early 2000s contact lens solutions approved by the FDA were widely marketed as “no-rub” multipurpose solutions.¹²⁴ The FDA changed its recommendation in 2009 and now instructs users to rub reusable lenses.¹²⁴ It is possible that contact lens wearers during that time adopted habits of not rubbing their lenses and have continued to do so, despite solution bottles no longer having the words “no-rub” on their labels. It is important to teach lens wearers proper compliance guidelines when they begin lens wear, and to make a routine of updating lens wearers at annual exams on the latest guidelines.

Why are wearers noncompliant with replacement schedules? Some patients may misconstrue or be confused about advised replacement frequency. Others do so intentionally, with 3–9.3% saying the behavior was approved by their eye care provider.^{19,72} More common reasons for this behavior include forgetting when to replace lenses (18.5–53%), forgetting to order needed contact lenses (11–22.2%), or trying to save money by purchasing fewer lenses, as reported by 14.8–32% of lens wearers in various studies.^{1,19,42,72} Other common reasons for non-compliance with contact lens care include complexity of care procedures, poor understanding of instructions, strained patient-practitioner relationships, time constraints, cost, and forgetfulness.^{36,38,119,125} Furthermore, factors such as age, educational attainment, and living arrangements affect compliance but are challenging to modify. Living environment complexities, for example may not be perceived as actionable by patients or known by practitioners, necessitating discussions between the practitioner and the lens wearer, in order to make tailored, practical advice from providers possible.¹²⁶

Current Techniques for Improving Compliance

The findings presented above show that non-compliant contact lens behavior is common, although not always intentional. To determine how to improve patient compliance, it is beneficial to explore techniques used in patient education that have

been successful to date and understand how patients best learn new information. For example, average learning retention rates for different kinds of teaching vary from approximately 5% for a lecture, 10% for reading once, 20% for a demonstration, 30% for a discussion group, 75% for practice by doing and 90% for teaching others.¹²⁷ Combining teaching methods, especially incorporating practice by doing, can enhance learning outcomes, though it requires additional time. Hibbard et al found that engaged patients are curious about their health situation and feel accountable concerning their health care; thus, they may pay additional attention to information related to their health situation.¹²⁸ Patient attitude toward compliance may be helped by information which explains why compliant procedures are necessary for long-term success.¹²⁹ Strategies practitioners can consider when striving to improve patient compliance are presented below.

Improving Contact Lens Care Compliance

1. **Patient-Practitioner Communication:** There is a need for clearer, more patient-centered communication between eye care providers and patients. This includes using simple language, visual aids (eg, infographics and videos), and providing actionable feedback.¹²⁶ Communication with patients should be easy to understand, repetitive, and specific; minimize jargon; and check for patient understanding in order to ensure patient comprehension.^{129–132} Written materials should be presented clearly, ideally at an eighth-grade reading level, and should complement verbal instructions.^{133,134} Similarly, educational information should be adapted to the patients' level of understanding and delivered in various formats, including printed handouts and electronic communications, to reinforce key messages.^{129,135,136} Health care recommendations that are presented clearly and simply, are of short duration, and include the positive effects on quality of life are related to good compliance levels.¹³⁷

Moreover, using relatable and empathetic communication enhances the practitioner-patient relationship, and building a strong relationship can enhance compliance. A higher intensity of practitioner involvement was found to be related to a greater level of patient compliance.⁴ Thompson et al discovered a direct correlation between the communication skills of the practitioner and the degree of compliance of his or her patients.¹³⁸ Empathetically relating to a patient's lens use with reference to a practitioner's own lens wearing and handling experiences can improve the practitioner/patient relationship. Lack of contact can weaken the influence of practitioner instructions, especially when patients are exposed to alternative sources of advice.¹³⁹ Compliance appears to be improved if information is presented in a manner that explains the contact lens instructions in a positive and enthusiastic manner.^{126,140} Nonverbal communication, such as attentive listening and eye contact, also contributes to patient satisfaction.^{141,142} Lastly, addressing specific patient needs and risk factors, such as living condition, personality,¹⁴³ and age, can help tailor educational efforts more effectively and improve compliance.¹³¹

2. **Patient Education and Reinforcement:** One-time instructions are often insufficient due to the amount of information needed by first-time wearers and the likelihood of forgetting some or all of it; additionally lack of reinforcement is a major barrier to compliance.^{139,144,145} Ongoing education and reinforcement, including follow-up visits and virtual reminders, are crucial for improving compliance.¹⁴⁶ Practitioners should emphasize the importance of follow-up examinations and regularly reinforce lens care and wearing schedules at each visit.^{38,53,126} Giving examples may be effective, such as explaining to patients that a study found that contact lens wear without annual follow-up visits was a predictor of eye complications when compared to contact lens wear with contact lens annual visits.¹¹⁵ Technicians involved in patient education should undergo ongoing training and certification to ensure they also provide effective instruction.^{119,132} Regular aftercare appears to be necessary for maintaining compliance and for having the opportunity to modify behavior and eliminate non-compliance.¹⁴¹ A 2007 study by Yung found that thorough explanation of lens care procedures both initially and at a 6-month follow up appointment enhanced participant compliance with overall proper lens-related behaviors, while adding quarterly compliance exercises sent by email only further improved compliance with case hygiene.¹⁴⁷

Although contact lens wearers may have a history of non-compliance with one or multiple aspects of lens care, continued, repeated emphasis of key items may still improve compliance.^{37,72,129,148} Incorporating practical

demonstrations and ongoing reinforcement through multiple formats (verbal, written, pictorial) can be helpful. One study found providing supplemental compliance commentary during insertion and removal training helped rationalize each of the recommended steps and raised both patient understanding of hygienic practices and overall compliance.¹³⁹ Employing strategies that address patients' learning retention issues, such as practical demonstrations and regular follow-ups, can help ensure that contact lens care instructions are understood and followed effectively.

3. **Behavioral and Attitudinal Change:** Compliance issues often stem from misunderstandings or lack of awareness, and practitioners often fall victim to blaming the patient for non-compliance rather than listening to patients and trying to understand the underlying reasons for their behaviors.⁹³ Emphasizing the benefits of correct lens care and providing practical, step-by-step instructions can help.⁹³ Patients may benefit from understanding the reasons behind recommended practices and seeing practical demonstrations.¹²⁰ Overemphasizing infection risks may be less effective due to their current lower prevalences.¹⁴⁹ Instead, focusing on discomfort, dryness, and cosmetic issues like redness may be more motivating for maintaining hygiene practices.¹⁴⁹ Eye care providers should continue to educate the public, stakeholders, and legislators about the medical nature of contact lenses, the importance of proper fitting, and the need for follow-up care to help behaviors and attitudes improve globally.¹¹⁹
4. **System and Safeguards:** All patients may exhibit non-compliance, and no single patient characteristic can predict non-compliance reliably.^{119,139} Even established wearers are not necessarily compliant and should be reminded of proper lens care at a minimum on an annual basis.¹³² Compliance with contact lens care is influenced by multiple factors, including education and the complexity of care regimens. Simplified care regimens and redundant safeguards are necessary to ensure patient safety and adherence to recommended lens care routines. Systems should incorporate redundancies to minimize risks even when patients may not fully adhere to instructions. Practitioners should actively engage with patients, provide repeated and varied educational inputs, and address non-compliance issues promptly.⁴ Both patients and professionals need to better recognize and understand specific non-compliance issues and their consequences to improve patient education and adherence.²⁹
5. **Role of Social and Educational Tools:** When prescribing contact lenses, utilizing only verbal and written education strategies are not sufficient in meeting patient educational needs.¹³³ Although nothing can replace in-person education, utilizing social media, email, and patient portals for ongoing education and reminders can enhance adherence.¹³⁶ Email can be a more efficient and cost-effective method for sending reminders and educational materials compared to traditional hard copies.¹²⁹ Reducing information overload by presenting instructions at the initial visit and using email for lens care reminders can help better manage patient compliance over time.^{60,139,149} Other reports recommend supplying education materials on a company website, if available, to provide patients with an additional source of information accessible without the need for in-person contact.¹³³

Additionally, infographics and pictograms are particularly useful for improving comprehension,¹⁵⁰ especially among patients with lower literacy levels.¹²⁶ Providing written instructions reinforces verbal education and improves patient compliance. Delp and Jones discovered that patients who had received information by means of cartoon illustrations were more prone to read the instructions, understand what was expressed, and most importantly, comply with the given instructions.¹⁵¹ Similar findings were encountered by Michielutte et al when comparing information given in narrative style plain bullet-type sentences versus illustrated texts.¹⁵² Moreover, detailed and well-designed leaflets are preferred by patients for clarity and usability,¹⁵³ and an integrated booklet with warnings adjacent to relevant procedural steps and rationale produced the best compliance rates among users.⁴ Effective communication between optometrists and patients is crucial, and incorporating new strategies, like multimedia messages, can enhance patient compliance and reduce complications. Social media is available to everyone, including non-experts. Having a presence online for patients to visit, especially when posting friendly messages about proper lens care and reasons for compliance could combat the misinformation that is so widely available to patients every time they are online.

By addressing these areas, eye care professionals can improve patient understanding, adherence, and overall safety in contact lens use, ultimately leading to better patient outcomes and reduced risk of complications. Applying structured,

repeatable education and reinforcement strategies can significantly enhance patient engagement and compliance. By using in-person discussions during exams - partnered with paper, digital, and multi-media materials - practitioners can communicate in a way that resonates with patients.

Conclusion

Compliance with proper contact lens behaviors is critical to successful contact lens wear. Consequences of poor compliance are many, ranging from mild discomfort to sight-threatening ocular sequelae. Presented herein are suggestions to prevent these complications and promote better compliance.

Disclosure

Dr Jennifer Fogt reports research funding from Vyluma, Eyenovia, Bausch + Lomb, Alcon, Cooper Vision, Interojo, Vizionfocus, Myoptechs; personal fees from TearOptix, Envision Biomedical and Hoya, outside the submitted work. The authors report no other conflicts of interest in this work.

References

1. Dumbleton KA, Woods CA, Jones LW, Fonn D. The relationship between compliance with lens replacement and contact lens-related problems in silicone hydrogel wearers. *Cont Lens Anterior Eye*. 2011;34(5):216–222. doi:10.1016/j.clae.2011.03.001
2. Tilia D, Lazon de la Jara P, Zhu H, Naduvilath TJ, Holden BA. The effect of compliance on contact lens case contamination. *Optom Vis Sci*. 2014;91(3):262–271. doi:10.1097/OPX.0000000000000163
3. Dart JK, Radford CF, Minassian D, Verma S, Stapleton F. Risk factors for microbial keratitis with contemporary contact lenses: a case-control study. *Ophthalmology*. 2008;115(10):1647–1654. doi:10.1016/j.ophtha.2008.05.003
4. Claydon BE, Efron N. Non-compliance in contact lens wear. *Ophthalmic Physiol Opt*. 1994;14(4):356–364.
5. Zaki M, Pardo J, Carracedo G. A review of international medical device regulations: contact lenses and lens care solutions. *Cont Lens Anterior Eye*. 2019;42(2):136–146. doi:10.1016/j.clae.2018.11.001
6. Healthy Contact Lens Wear and Care. U.S. Centers for Disease Control and Prevention; 2024. Available from: <https://www.cdc.gov/contact-lenses/prevention/index.html>. Accessed July 26, 2024.
7. What you need to know about contact lens hygiene. American Optometric Association. Available from: <https://www.aoa.org/AOA/Documents/AOA%20More/ContactLensHygiene.pdf>. Accessed July 26, 2024.
8. Contact lenses Instructions and acknowledgement form. Optometry Australia; 2018. Available from: https://www.optometry.org.au/wp-content/uploads/GVFL/Brochure_PDFs/Contact-Lenses-2018-interactive-final.pdf. Accessed July 26, 2024.
9. Contact Lens Risks. U.S. Food and Drug Administration; 2018. Available from: <https://www.fda.gov/medical-devices/contact-lenses/contact-lens-risks>. Accessed July 12, 2024.
10. Boyd K How to take care of contact lenses. American Academy of Ophthalmology; 2022. Available from: <https://www.aao.org/eye-health/glasses-contacts/contact-lens-care>. Accessed July 26, 2024.
11. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings. recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America. *MMWR Recomm Rep*. 2002;51(Rr-16):1–45.
12. World Health Organization Guidelines Approved by the Guidelines Review Committee. *WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care is Safer Care*. Geneva: World Health Organization; 2009.
13. Tartari E, Bellissimo-Rodrigues F, Pires D, et al. Updates and future directions regarding hand hygiene in the healthcare setting: insights from the 3rd ICPIIC alcohol-based handrub (ABHR) task force. *Antimicrob Resist Infect Control*. 2024;13(1):26. doi:10.1186/s13756-024-01374-9
14. Hart KM, Stapleton F, Carnt N, Arundel L, Lian KY. Optometry Australia's infection control guidelines 2020. *Clin Exp Optom*. 2021;104(3):267–284. doi:10.1080/08164622.2021.1887704
15. Lian KY, Napper G, Stapleton FJ, Kiely PM. Infection control guidelines for optometrists 2016. *Clin Exp Optom*. 2017;100(4):341–356. doi:10.1111/cxo.12544
16. About Handwashing. Clean Hands; 2024. Available from: https://www.cdc.gov/clean-hands/about/index.html#cdc_health_safety_special_topic_resources-resources. Accessed July 11, 2024.
17. Ohlenschlaeger J, Friberg J, Ramsing D, Agner T. Temperature dependency of skin susceptibility to water and detergents. *Acta Derm Venereol*. 1996;76(4):274–276. doi:10.2340/0001555576274276
18. Berardesca E, Vignoli GP, Distanti F, Brizzi P, Rabbiosi G. Effects of water temperature on surfactant-induced skin irritation. *Contact Dermatitis*. 1995;32(2):83–87. doi:10.1111/j.1600-0536.1995.tb00751.x
19. Naaman NK, Alharbi SY, Khan MA, Alghamdi SA. Compliance with contact lens care and factors driving noncompliance in health-care students in Jeddah, Saudi Arabia. *Saudi J Ophthalmol*. 2022;36(1):75–82. doi:10.4103/SJOPT.SJOPT_202_21
20. Morgan PB, Efron N, Toshida H, Nichols JJ. An international analysis of contact lens compliance. *Cont Lens Anterior Eye*. 2011;34(5):223–228. doi:10.1016/j.clae.2011.08.001
21. Ramamoorthy P, Nichols JJ. Compliance factors associated with contact lens-related dry eye. *Eye Contact Lens*. 2014;40(1):17–22. doi:10.1097/ICL.000000000000009
22. Gyawali R, Nestha Mohamed F, Bist J, Kandel H, Marasini S, Khadka J. Compliance and hygiene behaviour among soft contact lens wearers in the Maldives. *Clin Exp Optom*. 2014;97(1):43–47. doi:10.1111/cxo.12069

23. Zengin H, Çaka SY, Özdede EE, Tatar İT, Çınar N. Knowledge, practices and use of contact lenses among university students in Turkey. *Malawi Med J*. 2021;33(4):253–260. doi:10.4314/mmj.v33i4.5
24. Albasheer O, Gosadi IM, Abuallut I, et al. Awareness and hygiene practices among contact lens wearers: a population-based cross-sectional survey. *Cureus*. 2024;16(2):e54723. doi:10.7759/cureus.54723
25. Taslipinar Uzel AG, Uzel MM, Yuksel N, Akcay EK. Contact lens compliance with ophthalmologists and other health professionals. *Eye Contact Lens*. 2018;44(Suppl 2):S127–S130. doi:10.1097/ICL.0000000000000439
26. Bui TH, Cavanagh HD, Robertson DM. Patient compliance during contact lens wear: perceptions, awareness, and behavior. *Eye Contact Lens*. 2010;36(6):334–339. doi:10.1097/ICL.0b013e3181f579f7
27. Sapkota K. Level of compliance in contact lens wearing medical doctors in Nepal. *Cont Lens Anterior Eye*. 2015;38(6):456–460. doi:10.1016/j.clae.2015.05.010
28. Ocansey S, Ovenseri Ogbomo G, Abu EK, Morny EKA, Adjei-Boye O. Profile, knowledge, and attitude of contact lens users regarding contact lens wear in Ghana. *Cont Lens Anterior Eye*. 2019;42(2):170–177. doi:10.1016/j.clae.2018.10.012
29. Barisic Kutija M, Kuzman T, Kalauz M, et al. Lens care compliance rates and perceptions among rigid gas permeable contact lens wearers - a pilot study. *Acta Clin Croat*. 2022;61(2):198–205. doi:10.20471/acc.2022.61.02.05
30. Bakkar MM, Alzghoul EA. Assessment of compliance with contact lens wear and care among university-based population in Jordan. *Cont Lens Anterior Eye*. 2020;43(4):395–401. doi:10.1016/j.clae.2020.02.020
31. Khan MH, Mubeen SM, Chaudhry TA, Khan SA. Contact lens use and its compliance for care among healthcare workers in Pakistan. *Indian J Ophthalmol*. 2013;61(7):334–337. doi:10.4103/0301-4738.97552
32. Khoza N, Moodley T, Sokhulu S, et al. Knowledge, attitudes and practices of contact lens use in a South African adolescent population. *Afr Health Sci*. 2020;20(2):768–774. doi:10.4314/ahs.v20i2.29
33. Robertson DM, Cavanagh HD. Non-compliance with contact lens wear and care practices: a comparative analysis. *Optom Vis Sci*. 2011;88(12):1402–1408. doi:10.1097/OPX.0b013e3182333cf9
34. Zhu Q, Yang B, Deng N, et al. The use of contact lenses among university students in Chengdu: knowledge and practice of contact lens wearers. *Cont Lens Anterior Eye*. 2018;41(2):229–233. doi:10.1016/j.clae.2017.12.008
35. Mingo-Botin D, Zamora J, Arnalich-Montiel F, Muñoz-Negrete FJ. Characteristics, behaviors, and awareness of contact lens wearers purchasing lenses over the internet. *Eye Contact Lens*. 2020;46(4):208–213. doi:10.1097/ICL.0000000000000702
36. Supiyaphun C, Jongkhajornpong P. Contact lens use patterns, behavior and knowledge among university students in Thailand. *Clin Ophthalmol*. 2021;15:1249–1258. doi:10.2147/OPTH.S304735
37. Wu Y, Carnt N, Stapleton F. Contact lens user profile, attitudes and level of compliance to lens care. *Cont Lens Anterior Eye*. 2010;33(4):183–188. doi:10.1016/j.clae.2010.02.002
38. Beshtawi IM, Qaddumi F, Suboh N, Zaid A, Mansour H, Zeyadeh T. Compliance of soft contact lens care and bacterial contamination among university students in palestine. *Clin Ophthalmol*. 2022;16:4121–4134. doi:10.2147/OPTH.S352209
39. Bian Z, Xu X, Chen D, Ni H. Assessment of patient compliance in orthokeratology and analysis of influencing factors: a cross-sectional study. *BMC Ophthalmol*. 2021;21(1):396. doi:10.1186/s12886-021-02148-2
40. Cardona G, Alonso S, Yela S. Compliance versus risk awareness with contact lens storage case hygiene and replacement. *Optom Vis Sci*. 2022;99(5):449–454. doi:10.1097/OPX.0000000000001881
41. Chalmers RL, Wagner H, Kinoshita B, et al. Is purchasing lenses from the prescriber associated with better habits among soft contact lens wearers? *Cont Lens Anterior Eye*. 2016;39(6):435–441. doi:10.1016/j.clae.2016.08.003
42. Dumbleton K, Richter D, Bergenske P, Jones LW. Compliance with lens replacement and the interval between eye examinations. *Optom Vis Sci*. 2013;90(4):351–358. doi:10.1097/OPX.0b013e318288afcb
43. Gammoh Y, Abdu M. Contact lens procurement and usage habits among adults in Sudan. *PLoS One*. 2021;16(5):e0251987. doi:10.1371/journal.pone.0251987
44. García-Ayuso D, Moya-Rodríguez E, Valiente-Soriano FJ, Galindo-Romero C, Sobrado-Calvo P, Di Pierdomenico J. University students fail to comply with contact lens care. *Cont Lens Anterior Eye*. 2022;45(2):101411. doi:10.1016/j.clae.2021.01.006
45. Hickson-Curran S, Chalmers RL, Riley C. Patient attitudes and behavior regarding hygiene and replacement of soft contact lenses and storage cases. *Cont Lens Anterior Eye*. 2011;34(5):207–215. doi:10.1016/j.clae.2010.12.005
46. Udomwech L, Karnjana K, Jewboonchu J, et al. Bacterial microbiota of the contact lens surface and associated care behaviours. *Heliyon*. 2022;8(3):e09038. doi:10.1016/j.heliyon.2022.e09038
47. Vianya-Estopa M, Wolffsohn JS, Beukes E, Trott M, Smith L, Allen PM. Soft contact lens wearers' compliance during the COVID-19 pandemic. *Cont Lens Anterior Eye*. 2021;44(4):101359. doi:10.1016/j.clae.2020.08.003
48. Gammoh Y, Asfour W. Compliance to contact lens wear and care among Jordanian adults. *PLoS One*. 2023;18(1):e0280409. doi:10.1371/journal.pone.0280409
49. Çavdarlı C, Bayraktar N, Kılıç M. Survey of hygiene, behaviours, and awareness regarding contact lens wear with conventional and novel questions. *Clin Exp Optom*. 2021;104(4):491–498. doi:10.1080/08164622.2021.1878848
50. Cardona G, Alonso S, Busquets A. Patient - practitioner communication and contact lens compliance during a prolonged COVID-19 lockdown. *Cont Lens Anterior Eye*. 2021;44(6):101433. doi:10.1016/j.clae.2021.02.019
51. Dumbleton KA, Spafford MM, Sivak A, Jones LW. Exploring compliance: a mixed-methods study of contact lens wearer perspectives. *Optom Vis Sci*. 2013;90(8):898–908. doi:10.1097/OPX.0b013e3182956c46
52. Ibrahim NK, Seraj H, Khan R, Baabdullah M, Reda L. Prevalence, habits and outcomes of using contact lenses among medical students. *Pak J Med Sci*. 2018;34(6):1429–1434. doi:10.12669/pjms.346.16260
53. Lim CHL, Carnt NA, Farook M, et al. Risk factors for contact lens-related microbial keratitis in Singapore. *Eye*. 2016;30(3):447–455. doi:10.1038/eye.2015.250
54. Stapleton F, Naduvilath T, Keay L, et al. Risk factors and causative organisms in microbial keratitis in daily disposable contact lens wear. *PLoS One*. 2017;12(8):e0181343. doi:10.1371/journal.pone.0181343
55. Szczotka-Flynn LB, Shovlin JP, Schnider CM, et al. American academy of optometry microbial Keratitis Think Tank. *Optom Vis Sci*. 2021;98(3):182–198. doi:10.1097/OPX.0000000000001664

56. Arshad M, Carnt N, Tan J, Stapleton F. Effect of water exposure on contact lens storage case contamination in soft lens wearers. *Optom Vis Sci.* **2021**;98(9):1002–1010. doi:10.1097/OPX.0000000000001772
57. Ramos-Davila EM, Ruiz-Lozano RE, Gutierrez-Juarez K, et al. Knowledge and compliance with contact lens care: a population-based study at a referral center in Northeast Mexico. *Cont Lens Anterior Eye.* **2024**;47(2):102126. doi:10.1016/j.clae.2024.102126
58. Zimmerman AB, Richdale K, Mitchell GL, et al. Water exposure is a common risk behavior among soft and gas-permeable contact lens wearers. *Cornea.* **2017**;36(8):995–1001. doi:10.1097/ICO.0000000000001204
59. Kuzman T, Kutija MB, Masnec S, et al. Compliance among soft contact lens wearers. *Coll Antropol.* **2014**;38(4):1217–1221.
60. Ariwaka Y, Ichijima H, Shimamoto S, Sakata H, Cavanagh HD. Effects of a contact lens subscriber replacement program on patient lens care behavior in Japan. *Cont Lens Anterior Eye.* **2016**;39(1):47–52. doi:10.1016/j.clae.2015.08.001
61. Kuzman T, Kutija MB, Juri J, et al. Lens wearers non-compliance - is there an association with lens case contamination? *Cont Lens Anterior Eye.* **2014**;37(2):99–105. doi:10.1016/j.clae.2013.08.004
62. Wu YT, Tran J, Truong M, Harmis N, Zhu H, Stapleton F. Do swimming goggles limit microbial contamination of contact lenses? *Optom Vis Sci.* **2011**;88(4):456–460. doi:10.1097/OPX.0b013e31820f15a6
63. Sapkota K, Lira M, Martin R, Bhattarai S. Ocular complications of soft contact lens wearers in a tertiary eye care centre of Nepal. *Cont Lens Anterior Eye.* **2013**;36(3):113–117. doi:10.1016/j.clae.2012.11.002
64. Stellwagen A, MacGregor C, Kung R, Konstantopoulos A, Hossain P. Personal hygiene risk factors for contact lens-related microbial keratitis. *BMJ Open Ophthalmol.* **2020**;5(1):e000476. doi:10.1136/bmjophth-2020-000476
65. Siddiqui R, Khan NA. Biology and pathogenesis of Acanthamoeba. *Parasit Vectors.* **2012**;5(1):6. doi:10.1186/1756-3305-5-6
66. Stockman LJ, Wright CJ, Visvesvara GS, Fields BS, Beach MJ. Prevalence of Acanthamoeba spp. and other free-living amoebae in household water, Ohio, USA—1990–1992. *Parasitol Res.* **2011**;108(3):621–627. doi:10.1007/s00436-010-2120-7
67. de Lacerda AG, Lira M. Acanthamoeba keratitis: a review of biology, pathophysiology and epidemiology. *Ophthalmic Physiol Opt.* **2021**;41(1):116–135. doi:10.1111/opo.12752
68. Joslin CE, Tu EY, Shoff ME, et al. The association of contact lens solution use and acanthamoeba Keratitis. *Am J Ophthalmol.* **2007**;144(2):169–180.e162. doi:10.1016/j.ajo.2007.05.029
69. Szczotka-Flynn LB, Pearlman E, Ghannoum M. Microbial contamination of contact lenses, lens care solutions, and their accessories: a literature review. *Eye & Contact Lens.* **2010**;36(2):116–129. doi:10.1097/ICL.0b013e3181d20cae
70. Shigeyasu C, Yamada M, Fukuda M, et al. Severe ocular complications associated with wearing of contact lens in Japan. *Eye & Contact Lens.* **2022**;48(2):63–68. doi:10.1097/ICL.0000000000000870
71. Reusable contact lenses daily care. British Contact Lens Association; **2022**. Available from: <file:///C:/Users/fogt.78/Downloads/BCLA%20Contact%20Lens%20Dos%20and%20Donts%20Monthly.pdf>. Accessed July 26, 2024.
72. Dumbleton K, Richter D, Woods C, Jones L, Fonn D. Compliance with contact lens replacement in Canada and the United States. *Optom Vis Sci.* **2010**;87(2):131–139. doi:10.1097/OPX.0b013e3181ca32dc
73. Rueff EM, Wolfe J, Bailey MD. A study of contact lens compliance in a non-clinical setting. *Cont Lens Anterior Eye.* **2019**;42(5):557–561. doi:10.1016/j.clae.2019.03.001
74. Gray TB, Cursons RT, Sherwan JF, Rose PR. Acanthamoeba, bacterial, and fungal contamination of contact lens storage cases. *Br J Ophthalmol.* **1995**;79(6):601. doi:10.1136/bjo.79.6.601
75. Thakur DV, Gaikwad UN. Microbial contamination of soft contact lenses & accessories in asymptomatic contact lens users. *Indian J Med Res.* **2014**;140(2):307–309.
76. Donlan RM, Costerton JW. Biofilms: survival mechanisms of clinically relevant microorganisms. *Clin Microbiol Rev.* **2002**;15(2):167–193. doi:10.1128/CMR.15.2.167-193.2002
77. Wu YT, Zhu H, Willcox M, Stapleton F. Removal of biofilm from contact lens storage cases. *Invest Ophthalmol Vis Sci.* **2010**;51(12):6329–6333. doi:10.1167/iovs.10-5796
78. Boost M, Shi GS, Cho P. Adherence of acanthamoeba to lens cases and effects of drying on survival. *Optom Vis Sci.* **2011**;88(6):703–707. doi:10.1097/OPX.0b013e318215c316
79. Wu YT, Zhu H, Willcox M, Stapleton F. Impact of air-drying lens cases in various locations and positions. *Optom Vis Sci.* **2010**;87(7):465–468. doi:10.1097/OPX.0b013e3181e172a1
80. Barker J, Jones MV. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. *J Appl Microbiol.* **2005**;99(2):339–347. doi:10.1111/j.1365-2672.2005.02610.x
81. Goforth MP, Boone SA, Clark J, et al. Impacts of lid closure during toilet flushing and of toilet bowl cleaning on viral contamination of surfaces in United States restrooms. *Am J Infect Control.* **2023**;2023:1.
82. Stapleton F, Dart J. Pseudomonas keratitis associated with biofilm formation on a disposable soft contact lens. *Br J Ophthalmol.* **1995**;79(9):864–865. doi:10.1136/bjo.79.9.864
83. Wiley L, Bridge DR, Wiley LA, Odom JV, Elliott T, Olson JC. Bacterial biofilm diversity in contact lens-related disease: emerging role of achromobacter, stentrophomonas, and Delftia. *Invest Ophth Vis Sci.* **2012**;53(7):3896–3905. doi:10.1167/iovs.11-8762
84. McLaughlin-Borlace L, Stapleton F, Matheson M, Dart JK. Bacterial biofilm on contact lenses and lens storage cases in wearers with microbial keratitis. *J Appl Microbiol.* **1998**;84(5):827–838. doi:10.1046/j.1365-2672.1998.00418.x
85. Ishak B, Azizan ANA, Mariappan V. Knowledge and compliance among contact lens wearers living in kuala lumpur, Malaysia: a cross-sectional study. *Malays J Med Sci.* **2022**;29(5):126–132. doi:10.21315/mjms2022.29.5.13
86. Cope JR, Collier SA, Rao MM, et al. Contact lens wearer demographics and risk behaviors for contact lens-related eye infections—united states, 2014. *MMWR Morb Mortal Wkly Rep.* **2015**;64(32):865–870. doi:10.15585/mmwr.mm6432a2
87. Verani JR, Loric SA, Yoder JS, et al. National outbreak of Acanthamoeba keratitis associated with use of a contact lens solution, United States. *Emerg Infect Dis.* **2009**;15(8):1236–1242. doi:10.3201/eid1508.090225
88. Patel A, Hammersmith K. Contact lens-related microbial keratitis: recent outbreaks. *Current Opinion in Ophthalmol.* **2008**;19(4):302–306. doi:10.1097/ICU.0b013e3183045e74
89. Butcko V, McMahon TT, Joslin CE, Jones L. Microbial keratitis and the role of rub and rinsing. *Eye Contact Lens.* **2007**;33(6 Pt 2):421–423. discussion 424–425. doi:10.1097/ICL.0b013e318157f3df

90. Brown AC, Ross J, Jones DB, et al. Risk factors for acanthamoeba keratitis-a multistate case-control study, 2008-2011. *Eye Contact Lens*. 2018;44(Suppl 1):S173-s178. doi:10.1097/ICL.0000000000000365
91. Stapleton F, Edwards K, Keay L, et al. Risk factors for moderate and severe microbial keratitis in daily wear contact lens users. *Ophthalmology*. 2012;119(8):1516-1521. doi:10.1016/j.ophtha.2012.01.052
92. Lutmer KM, Wagner H, Richdale K, Zimmerman AB, Datta A, Dougherty BE. Examining daily disposable soft contact lens wearers' attitudes and beliefs using the Health Belief Model. *Ophthalmic Physiol Opt*. 2023;43(2):202-211. doi:10.1111/opo.13078
93. Livi S, Zeri F, Baroni R. Health beliefs affect the correct replacement of daily disposable contact lenses: predicting compliance with the health belief model and the theory of planned behaviour. *Cont Lens Anterior Eye*. 2017;40(1):25-32. doi:10.1016/j.clae.2016.09.003
94. Yeung KK, Forister JF, Forister EF, Chung MY, Han S, Weissman BA. Compliance with soft contact lens replacement schedules and associated contact lens-related ocular complications: the UCLA Contact Lens Study. *Optometry*. 2010;81(11):598-607. doi:10.1016/j.optm.2010.01.013
95. Dumbleton K, Woods C, Jones L, Richter D, Fonn D. Comfort and vision with silicone hydrogel lenses: effect of compliance. *Optom Vis Sci*. 2010;87(6):421-425. doi:10.1097/OPX.0b013e3181d95aea
96. Efron N, Morgan PB, Woods CA, Jones D, Jones L, Nicholas JJ. International trends in rigid contact lens prescribing (2000-2023): an update. *Cont Lens Anterior Eye*. 2024;47(5):102255. doi:10.1016/j.clae.2024.102255
97. Efron N, Tanner JOE. Chapter 20 - Reusable Lenses. In: Efron N, editor. *Contact Lens Practice. Fourth Edition* ed. New Delhi: Elsevier; 2024:196-208.e191.
98. Jones L, Woods CA, Efron N. Life expectancy of rigid gas permeable and high water content contact lenses. *Clao j*. 1996;22(4):258-261.
99. Lakkis C, Lorenz KO, Mayers M. Topical review: contact lens eye health and safety considerations in government policy development. *Optometry Vision Sci*. 2022;99(10):737-742. doi:10.1097/OPX.0000000000001937
100. Stapleton F, Bakkar M, Carnt N, et al. CLEAR - Contact lens complications. *Cont Lens Anterior Eye*. 2021;44(2):330-367. doi:10.1016/j.clae.2021.02.010
101. Stapleton F, Keay L, Edwards K, et al. The incidence of contact lens-related microbial keratitis in Australia. *Ophthalmology*. 2008;115(10):1655-1662. doi:10.1016/j.ophtha.2008.04.002
102. Bullimore MA, Sinnott LT, Jones-Jordan LA. The risk of microbial keratitis with overnight corneal reshaping lenses. *Optometry Vision Sci*. 2013;90(9):937-944. doi:10.1097/OPX.0b013e31829cae92
103. Schornack MHJ, Barr J, Shorter E, Nau A, Nau C. Complications of Scleral Lens Wear. *Invest Ophthalmol Vis Sci*. 2016;2016:1467.
104. Smith GT, Mireskandari K, Pullum KW. Corneal swelling with overnight wear of scleral contact lenses. *Cornea*. 2004;23(1):29-34. doi:10.1097/00003226-200401000-00005
105. Ercan ZE. Effect of eyeliner and mascara use on tear film and meibomian glands. *Saudi J Ophthalmol*. 2022;36(1):113-116. doi:10.4103/sjopt.sjopt_170_21
106. Prabhasawat P, Chirapapaian C, Chitkornkijsin C, Pinitpuwadol W, Saiman M, Veeraburion A. Eyeliner induces tear film instability and meibomian gland dysfunction. *Cornea*. 2020;39(4):473-478. doi:10.1097/ICO.0000000000002198
107. Kim CK, Carter S, Kim C, et al. Risk factors for meibomian gland disease assessed by meibography. *Clin Ophthalmol*. 2023;17:3331-3339. doi:10.2147/OPHT.S428468
108. Terry RL, Schnider CM, Holden BA, et al. CCLRU standards for success of daily and extended wear contact lenses. *Optom Vis Sci*. 1993;70(3):234-243. doi:10.1097/00006324-199303000-00011
109. McMonnies CW. An amplifying cascade of contact lens-related end-of-day hyperaemia and dryness symptoms. *Curr Eye Res*. 2018;43(7):839-847. doi:10.1080/02713683.2018.1457163
110. Papas EB, Tilia D, Tomlinson D, et al. Consequences of wear interruption for discomfort with contact lenses. *Optom Vis Sci*. 2014;91(1):24-31. doi:10.1097/OPX.0000000000000102
111. Fogt JS. Midday fogging of scleral contact lenses: current perspectives. *Clin Optim (Auckl)*. 2021;13:209-219. doi:10.2147/OPHTO.S284634
112. Fogt JS, Nau C, Harthan J, et al. Lens and solution properties in patients with and without midday fogging. *Ophthalmic Physiol Opt*. 2024;44(4):769-773. doi:10.1111/opo.13293
113. Schornack MM, Fogt J, Harthan J, et al. Factors associated with patient-reported midday fogging in established scleral lens wearers. *Cont Lens Anterior Eye*. 2020;43(6):602-608. doi:10.1016/j.clae.2020.03.005
114. Walker MK, Bergmanson JP, Miller WL, Marsack JD, Johnson LA. Complications and fitting challenges associated with scleral contact lenses: a review. *Cont Lens Anterior Eye*. 2016;39(2):88-96. doi:10.1016/j.clae.2015.08.003
115. Ifrah R, Quevedo L, Hazrati G, et al. Contact lens wear and follow-up and its association with signs and symptoms of meibomian gland dysfunction. *Ophthalmic Physiol Opt*. 2024;44(1):153-167. doi:10.1111/opo.13247
116. Chen EY, Myung Lee E, Loc-Nguyen A, Frank LA, Parsons Malloy J, Weissman BA. Value of routine evaluation in asymptomatic soft contact lens wearers. *Contact Lens Anterior Eye*. 2020;43(5):484-488. doi:10.1016/j.clae.2020.02.014
117. de Oliveira PR, Temporini-Nastari ER, Ruiz Alves M, Kara-José N. Self-evaluation of contact lens wearing and care by college students and health care workers. *Eye Contact Lens*. 2003;29(3):164-167. doi:10.1097/01.ICL.0000072829.76899.B5
118. Collins MJ, Carney LG. Patient compliance and its influence on contact lens wearing problems. *Am J Optom Physiol Opt*. 1986;63(12):952-956. doi:10.1097/00006324-198612000-00004
119. Donshik PC, Ehlers WH, Anderson LD, Suchecki JK. Strategies to better engage, educate, and empower patient compliance and safe lens wear: compliance: what we know, what we do not know, and what we need to know. *Eye Contact Lens*. 2007;33(6 Pt 2):430-433. discussion 434. doi:10.1097/ICL.0b013e318157f62a
120. Cho P, Boost M. Rivers and mountains may change, human nature does not! (traditional Chinese saying). *Cont Lens Anterior Eye*. 2009;32(4):155-156. doi:10.1016/j.clae.2009.06.001
121. Legarreta JE, Nau AC, Dhaliwal DK. Acanthamoeba keratitis associated with tap water use during contact lens cleaning: manufacturer guidelines need to change. *Eye Contact Lens*. 2013;39(2):158-161. doi:10.1097/ICL.0b013e31827a79ee
122. Steele KR, Zadnik K. Evaluation of rinsing options for rigid gas permeable contact lenses. *Eye Contact Lens*. 2023;49(9):386-391. doi:10.1097/ICL.0000000000001016
123. Steele KR, Wagner H, Lai N, Zimmerman AB. Gas-permeable contact lenses and water exposure: practices and perceptions. *Optom Vis Sci*. 2021;98(3):258-265. doi:10.1097/OPX.0000000000001660

124. Cho P, Poon HY, Chen CC, Yuen LT. To rub or not to rub? - effective rigid contact lens cleaning. *Ophthalmic Physiol Opt.* 2020;40(1):17–23. doi:10.1111/opo.12655
125. Dumbleton KA, Richter D, Woods CA, et al. A multi-country assessment of compliance with daily disposable contact lens wear. *Cont Lens Anterior Eye.* 2013;36(6):304–312. doi:10.1016/j.clae.2013.05.004
126. Lam D, Wagner H, Zimmerman AB, et al. Change in risk score and behaviors of soft contact lens wearers after targeted patient education. *Eye & Contact Lens.* 2022;48(8):347–354.
127. Coffey M, Gibbs G. Measuring teachers' repertoire of teaching methods. *Assess Eval Higher Educ.* 2002;27(4):383–390. doi:10.1080/0260293022000001382
128. Hibbard JH, Cunningham PJ. How engaged are consumers in their health and health care, and why does it matter? *Res Brief.* 2008;2008(8):1–9.
129. McMonnies CW. Improving contact lens compliance by explaining the benefits of compliant procedures. *Contact Lens Anterior Eye.* 2011;34(5):249–252. doi:10.1016/j.clae.2011.06.006
130. Konne NM, Collier SA, Spangler J, Cope JR. Healthy contact lens behaviors communicated by eye care providers and recalled by patients - united states, 2018. *MMWR Morb Mortal Wkly Rep.* 2019;68(32):693–697. doi:10.15585/mmwr.mm6832a2
131. King A, Hoppe RB. "Best practice" for patient-centered communication: a narrative review. *J Grad Med Educ.* 2013;5(3):385–393. doi:10.4300/JGME-D-13-00072.1
132. Lievens CW, Cilimberg KC, Moore A. Contact lens care tips for patients: an optometrist's perspective. *Clin Optim (Auckl).* 2017;9:113–121. doi:10.2147/OPTO.S139651
133. Falahati-Marvast F, Alipour F, Farokhzadian J, Ahmadian L. Determining the information needs of contact lens wearers for better education and more support: a qualitative study. *BMC Ophthalmol.* 2021;21(1):325. doi:10.1186/s12886-021-02085-0
134. Ebrahimzadeh H, Davalos R, Lee PP. Literacy levels of ophthalmic patient education materials. *Surv Ophthalmol.* 1997;42(2):152–156. doi:10.1016/S0039-6257(97)00027-1
135. Mayeaux EJ, Murphy PW, Arnold C, Davis TC, Jackson RH, Sentell T. Improving patient education for patients with low literacy skills. *Am Fam Physician.* 1996;53(1):205–211.
136. Alonso S, Yela S, Cardona G. Are patients sufficiently informed about contact lens wear and care? *Optom Vis Sci.* 2022;99(12):853–858. doi:10.1097/OPX.0000000000001964
137. Claydon BE, Efron N, Woods C. A prospective study of the effect of education on non-compliant behaviour in contact lens wear. *Ophthalmic Physiol Opt.* 1997;17(2):137–146. doi:10.1046/j.1475-1313.1997.96000579.x
138. Thompson B, Collins MJ, Hearn G. Clinician interpersonal communication skills and contact lens wearers' Motivation, Satisfaction, and Compliance. *Optometry Vision Sci.* 1990;67(9):673–678. doi:10.1097/00006324-199009000-00003
139. McMonnies CW. Improving patient education and attitudes toward compliance with instructions for contact lens use. *Cont Lens Anterior Eye.* 2011;34(5):241–248. doi:10.1016/j.clae.2011.06.007
140. Bennett ES, Stulc S, Bassi CJ, et al. Effect of patient personality profile and verbal presentation on successful rigid contact lens adaptation, satisfaction and compliance. *Optom Vis Sci.* 1998;75(7):500–505. doi:10.1097/00006324-199807000-00018
141. Ley P. Satisfaction, compliance and communication. *Br J Clin Psychol.* 1982;21(4):241–254. doi:10.1111/j.2044-8260.1982.tb00562.x
142. Roter DL, Frankel RM, Hall JA, Sluyter D. The expression of emotion through nonverbal behavior in medical visits. Mechanisms and outcomes. *J Gen Intern Med.* 2006;21(Suppl 1):S28–34. doi:10.1111/j.1525-1497.2006.00306.x
143. Carnt N, Keay L, Willcox M, Evans V, Stapleton F. Higher risk taking propensity of contact lens wearers is associated with less compliance. *Cont Lens Anterior Eye.* 2011;34(5):202–206. doi:10.1016/j.clae.2010.10.004
144. Huis A, Schoonhoven L, Grol R, et al. Helping hands: a cluster randomised trial to evaluate the effectiveness of two different strategies for promoting hand hygiene in hospital nurses. *Implement Sci.* 2011;6(1):101. doi:10.1186/1748-5908-6-101
145. Cardona G, Llovet I. Compliance amongst contact lens wearers: comprehension skills and reinforcement with written instructions. *Cont Lens Anterior Eye.* 2004;27(2):75–81. doi:10.1016/S1367-0484(04)00021-9
146. Aziz M, Erbad A, Belhaouari SB, Almourad MB, Altuwairiqi M, Ali R. Who uses mHealth apps? Identifying user archetypes of mHealth apps. *Digit Health.* 2023;9:20552076231152175. doi:10.1177/20552076231152175
147. Yung AM, Boost MV, Cho P, Yap M. The effect of a compliance enhancement strategy (self-review) on the level of lens care compliance and contamination of contact lenses and lens care accessories. *Clin Exp Optim.* 2007;90(3):190–202. doi:10.1111/j.1444-0938.2007.00147.x
148. Wu YT, Willcox M, Zhu H, Stapleton F. Contact lens hygiene compliance and lens case contamination: a review. *Cont Lens Anterior Eye.* 2015;38(5):307–316. doi:10.1016/j.clae.2015.04.007
149. McMonnies CW. Hand hygiene prior to contact lens handling is problematical. *Cont Lens Anterior Eye.* 2012;35(2):65–70. doi:10.1016/j.clae.2011.11.003
150. Fayers T, Abdullah W, Walton V, Wilkins MR. Impact of written and photographic instruction sheets on patient behavior after cataract surgery. *J Cataract Refract Surg.* 2009;35(10):1739–1743. doi:10.1016/j.jcrs.2009.07.003
151. Delp C, Jones J. Communicating information to patients: the use of cartoon illustrations to improve comprehension of instructions. *Acad Emerg Med.* 1996;3(3):264–270. doi:10.1111/j.1553-2712.1996.tb03431.x
152. Michielutte R, Bahnson J, Dignan MB, Schroeder EM. The use of illustrations and narrative text style to improve readability of a health education brochure. *J Cancer Educ.* 1992;7(3):251–260. doi:10.1080/08858199209528176
153. Bernardini C, Ambrogi V, Fardella G, Perioli L, Grandolini G. How to improve the readability of the patient package leaflet: a survey on the use of colour, print size and layout. *Pharmacol Res.* 2001;43(5):437–444. doi:10.1006/phrs.2001.0798

Clinical Optometry

Dovepress

Publish your work in this journal

Clinical Optometry is an international, peer-reviewed, open access journal publishing original research, basic science, clinical and epidemiological studies, reviews and evaluations on clinical optometry. All aspects of patient care are addressed within the journal as well as the practice of optometry including economic and business analyses. Basic and clinical research papers are published that cover all aspects of optics, refraction and its application to the theory and practice of optometry. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/clinical-optometry-journal>