The Ocular Surface 30 (2023) 240–253

Contents lists available at ScienceDirect

The Ocular Surface

journal homepage: www.elsevier.com/locate/jtos

TFOS Lifestyle Report Executive Summary: A Lifestyle Epidemic - Ocular Surface Disease

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A R T I C L E I N F O

Keywords:
Global consensus workshop
Contact lenses
Cosmetics
Digital environment
Elective medications
Environmental conditions
Evidence quality
Nutrition
Public awareness
Societal challenges
Dry eye
Ocular surface disease

A B S T R A C T

The Tear Film & Ocular Surface Society (TFOS) Workshop entitled ‘A Lifestyle Epidemic: Ocular Surface Disease’ was a global initiative undertaken to establish the direct and indirect impacts of everyday lifestyle choices and challenges on ocular surface health. This article presents an executive summary of the evidence-based conclusions and recommendations of the 10-part *TFOS Lifestyle Workshop* report. Lifestyle factors described within the report include contact lenses, cosmetics, digital environment, elective medications and procedures, environmental conditions, lifestyle challenges, nutrition, and societal challenges. For each topic area, the current literature was summarized and appraised in a narrative-style review and the answer to a key topic-specific question was sought using systematic review methodology. The *TFOS Lifestyle Workshop* report was published in its entirety in the April 2023 and July 2023 issues of *The Ocular Surface* journal. Links to downloadable versions of the document and supplementary material, including report translations, are available on the TFOS website: http://www.TearFilm.org.

1. Introduction [1]

Lifestyle is defined as the way in which a person lives. The lifestyle choices people make, and the challenges to which they are exposed, can affect many aspects of health, including that of the eye’s surface. The ocular surface is vulnerable to impacts from the external environment (e.g. lifestyle and societal challenges, environmental conditions and the digital environment), from directly applied products (e.g. contact lens wear and cosmetics) and from the internal environment (e.g. nutrition, and elective medications and procedures).

To promote awareness of possible effects of lifestyle choices on ocular surface health, the Tear Film & Ocular Surface Society (TFOS) launched the TFOS Workshop, entitled "A Lifestyle Epidemic: Ocular Surface Disease," in December 2020. This initiative reflected the TFOS mission to advance the research, literacy, and educational aspects of the scientific field of the tear film and ocular surface. The goal of the *TFOS Lifestyle Workshop* was to focus on the consequences of lifestyle choices, directly or indirectly, on the ocular surface and adnexa. Specifically, this Workshop addressed the impacts of contact lenses, cosmetics, digital environment, elective medications and procedures, environmental

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https://doi.org/10.1016/j.jtos.2023.08.009
Received 30 August 2023; Accepted 30 August 2023
Available online 1 September 2023

Table 1
Comparison of the typical characteristics of narrative and systematic reviews.

	NARRATIVE REVIEW	SYSTEMATIC REVIEW
FEATURES		
Scope of review question	Broad and overarching	Narrow and specific
Review protocol	Generally not developed	Should be established *a priori*
Literature sources and search strategies	Unlikely to be comprehensive, and may not be explicitly reported	Aims to be comprehensive, and should involve multiple databases, with explicitly defined and reproducible search strategies (including search dates)
Study selection process	Often not specified	Should be specifically detailed; best practice involves two independent review author assessments
Study selection criteria	Often not specified	Explicitly defined *a priori*
Risk of bias assessment of included studies	Generally not performed	Risk of bias assessment using established tools
Data extraction/summary process	Generally not defined	Required to be systematic and pre-specified
Evidence synthesis	Qualitative	Qualitative ± quantitative (meta-analyses)
CONSIDERATIONS		
Strengths	• Breadth of consideration of the subject matter • Scope to integrate preclinical and clinical findings • Development of narrative arguments	• Comprehensive synthesis of all evidence relevant to a specific question • Structured approaches and reporting guidelines aim to minimize bias • Certainty of the body of evidence can be determined using established approaches • Allows for assessment of publication bias
Weaknesses	• Typically, lack of pre-defined methods and lack of reproducibility increase risks of bias	• Restricted in scope (answers a focused question) • Resource intensive • Reporting biases may be amplified

conditions, lifestyle challenges, nutrition, and societal challenges on ocular surface health.

The *TFOS Lifestyle Workshop* involved the efforts of 158 clinical and basic science research experts from 38 countries, who utilized an evidence-based approach and a process of open communication, dialogue and transparency. Individuals who were assigned to Subcommittees, reviewed and discussed existing literature, identified gaps in knowledge, and proposed future directions for research. The search criteria are described in detail in the individual reports. Subcommittee reports were circulated among all Workshop participants, presented in open forum, and discussed in an interactive manner. This process required almost 2.5 years to complete.

The *TFOS Lifestyle Workshop* report was published in April 2023 in *The Ocular Surface*. Downloadable versions of the document are available on the TFOS website: www.tearfilm.org. It is anticipated that translations of the report will be offered in many languages, and, when completed, will also be available on the TFOS website.

An Executive Summary of the conclusions and recommendations of the TFOS Lifestyle Workshop report is presented in this article. The material is abstracted from the reports of nine *TFOS Lifestyle Workshop* Subcommittees. Additional details and all references can be obtained in the online versions.

2. Evidence quality [2]

An Evidence Quality Subcommittee was established as a new initiative for the *TFOS Lifestyle Workshop*, to provide methodological support and expertise to promote the use of consistent and advanced literature review methods, relating to both narrative and systematic review approaches, across the Workshop (Table 1). Evidence-based practice is an approach to healthcare that involves integrating the best-available research evidence with clinical expertise and patient preferences [3]. Inherent to this definition is ensuring the translation of the 'best' available, relevant, research evidence into practice. Identifying the 'best' evidence requires an assessment of the internal validity of the research, to determine if the methodology has minimized potential biases and errors.

A key focus of this Subcommittee was to assist with ensuring the appropriate evaluation and presentation of clinical evidence across the eight topic area reports (i.e., contact lenses, cosmetics, digital environment, elective medications and procedures, environmental conditions, lifestyle challenges, nutrition, and societal challenges), and to support capacity-building in evidence appraisal and encourage development of synthesis skills for the broader TFOS membership.

As outlined in the *TFOS Lifestyle - Evidence quality report* [2], the Evidence Quality Subcommittee contributed to two main aspects of each topic area report for the Workshop:

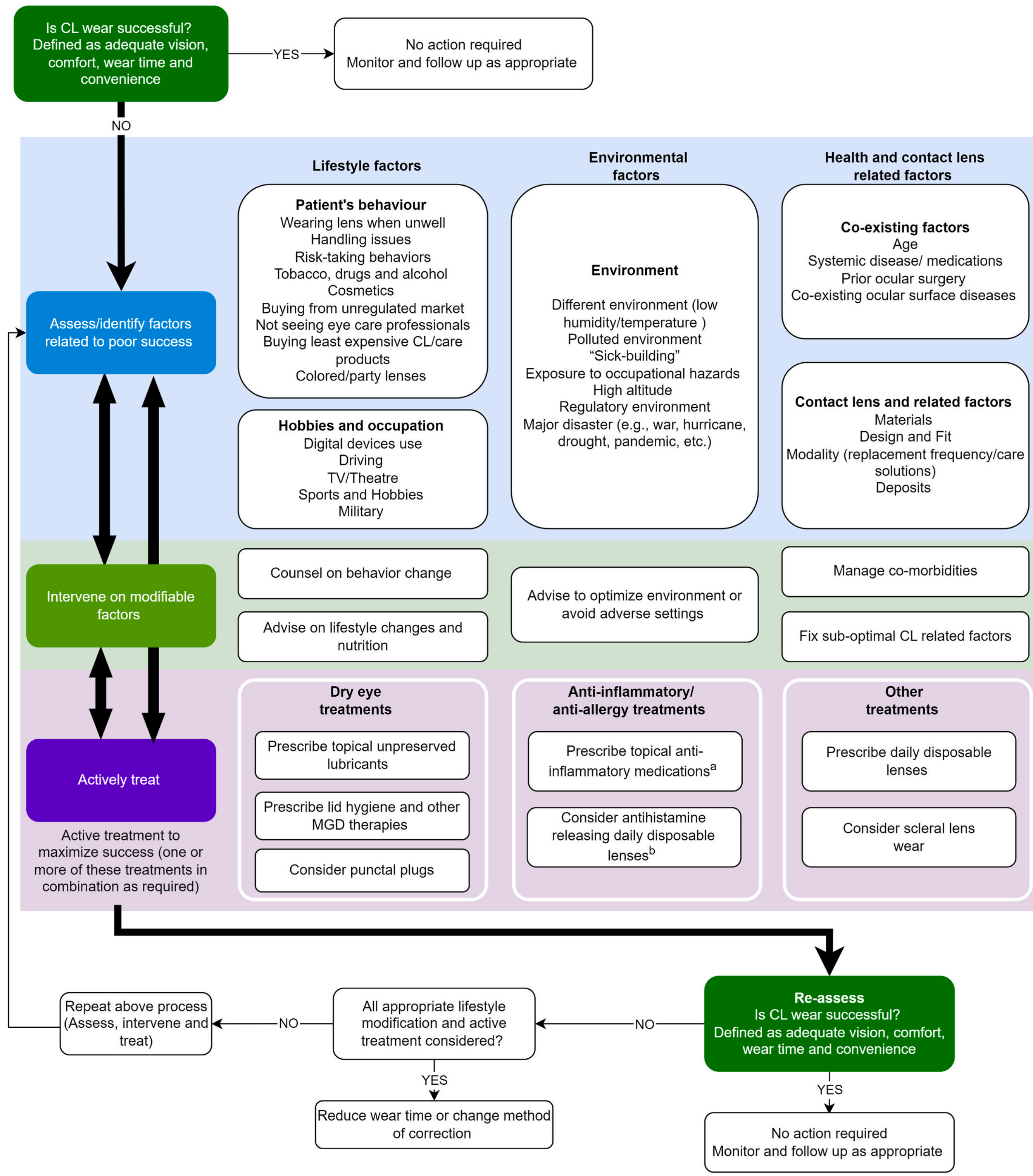
(i) *Narrative review:* supporting best practices for conducting and reporting narrative reviews, based on the framework defined in the Scale for the Quality Assessment of Narrative Review Articles (or SANRA) tool [4]. In addition, a process was implemented to support the citation and appropriate description of relevant and reliable systematic review evidence, and the transparent reporting of systematic reviews judged to be unreliable (when cited). Systematic review databases were curated for each topic area, derived from the *Cochrane Eyes and Vision United States (CEV@US) Database of Systematic Reviews in Eyes and Vision* [5]. This process identified a total of 754 systematic reviews, published between 1995 and 2021, that were considered broadly relevant to the 'ocular surface' and 'lifestyle factors'; of these, 281 (37%) were categorized as reliable based on evaluation to an accepted standard, with the remaining deemed unreliable. This finding emphasizes the importance of performing internal validity assessments on published studies, to assess their reliability and appropriately interpret their findings.

(ii) *Systematic review:* leading the undertaking of reliable reviews for a systematic evaluation of a high priority research question within each Subcommittee report. Standardized, reliable methods were adopted across all the systematic reviews completed as part of the *TFOS Lifestyle Workshop*, including an internal peer review process of draft protocols and outputs, prospective registration of the protocols on PROSPERO [6], comprehensive systematic literature searches, risk of bias assessments using validated tools, and the assessment of the certainty of the body of the evidence (where appropriate). This approach delivered clinically useful outputs for each topic area, and identified evidence gaps where future research can be prioritized. For most of the outcomes evaluated across the systematic reviews, only low or very low certainty evidence was identified. This finding highlights a need for further research to define the efficacy and/or safety of specific lifestyle interventions on the ocular surface, and to clarify relationships between specific lifestyle factors and ocular surface disease.

Finally, the Evidence Quality report describes the principal gains from implementing these processes, and makes suggestions for incorporation of such initiatives in future international taskforces and working groups.

3. Contact lenses [7]

Contact lenses have the capacity to enhance the lifestyle of individuals, primarily for the correction of refractive errors, but also for



[a]Oral or topical anti-inflammatory medications including oral fatty acids, medicinal honey, azithromycin, cyclosporine A, lifitegrast, diquafosol, and rebamipide
[b]In those with ocular allergies

Fig. 1. Summary of potential management strategies for contact lens discomfort. See original report for a complete description of this figure [7].

many other reasons, including medical indications. It is estimated that approximately 150 million people wear contact lenses globally and for those wearing contact lenses, numerous factors will govern wearer success. The *TFOS Lifestyle: Impact of contact lenses on the ocular surface* report investigates the contact lens choices that may impact the ocular surface and the lifestyle choices made by wearers that may impact contact lens wear and success.

The lens options chosen by practitioners can impact the ocular surface. Daily disposable lenses demonstrate the lowest degree of inflammatory responses, greatest level of convenience, highest level of compliance with respect to replacement, and the lowest complication rate.

The safety and performance of lenses are negatively impacted by non-adherence to replacing the lenses when scheduled, sleeping in lenses, poor wear and care of reusable lenses, especially with respect to topping off solutions, infrequently cleaning and replacing cases and exposing the lenses to tap water.

Lifestyle choices can impact the success and safety of contact lens wear. The avoidance of risky behaviors, such as sleeping in lenses, failing to comply with instructions from the eye care provider, failing to attend regular aftercare visits, purchasing contact lenses and solutions from unregulated vendors, wearing or sharing 'party' lenses, and using tobacco, alcohol or recreational drugs, can all increase the risk of adverse consequences. These adverse effects can range from reported dissatisfaction with contact lens wear to serious ocular compromise and permanent loss of vision. Strategies to ensure provision of adequate hygiene, safety education and ongoing connection with an eye care practitioner are needed, particularly for young adults who are often less compliant with respect to contact lens hygiene.

Wearing contact lenses in challenging atmospheric or work environments is potentially problematic, but in certain circumstances may confer protection. The coronavirus (COVID-19) pandemic also introduced challenges for contact lens wearers. Those restricted to working from home through choice or enforced lockdown might be engaged in more near vision activities, such as increased use of digital devices, requiring altered refractive considerations. Other untoward factors such as mask-associated dry eye and the potential for inadvertent injury from hand sanitizers entering the eye have also been described. A systematic review on lifestyle factors that lead to contact lens discontinuation, which occurs in approximately 25% of wearers over 2–3 years, revealed that further work is needed in order to acquire high quality data. The major known factors for contact lens dropout are discomfort, lens handling difficulties, and vision issues, with the last being particularly problematic in presbyopic wearers. A summary of potential management strategies for contact lens discomfort is shown in Fig. 1.

Examination of the literature resulted in an appreciation of the fact that several areas of study lack high quality evidence and would benefit from further exploration. These areas include determining the measures that should be taken when contact lens wearers are unwell with an upper respiratory tract infection, the impact of ocular surface disease on contact lens success (especially in older and naive wearers), and the impact of various environmental factors as well as mental health, stress and depression on contact lens performance with contemporary lens materials and modalities.

4. Cosmetics [8]

Eye cosmetics, or makeup, comprise a diverse array of products as (Fig. 2). They include concealers, conditioners, creams, extensions,

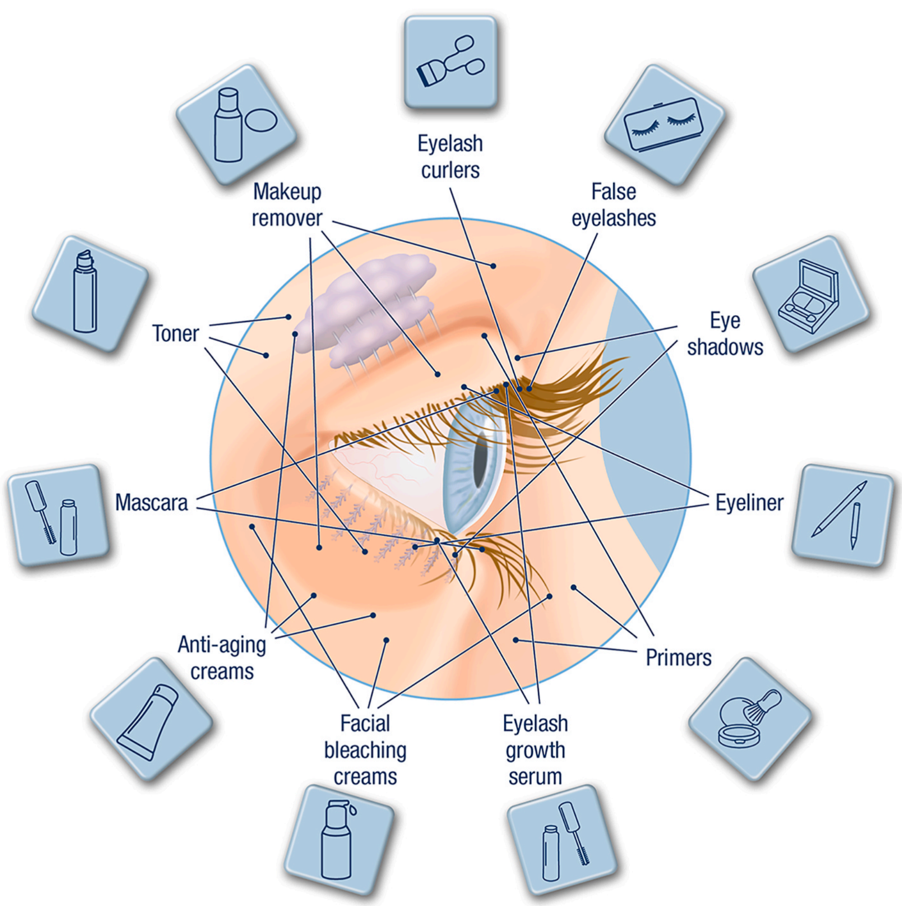


Fig. 2. Locations where eye makeup and cosmetic products are commonly applied [8].

eyeliners, foundations, glues, lotions, mascaras, moisturizers, primers, removers, serums, shadows, and toners. These products may be either leave-on or rinse-off. The ingredients in these cosmetics serve a myriad of purposes and are often included to function as an abrasive, absorbent, antimicrobial, antioxidant, buffer, colorant, emollient, emulsifier, film-former, humectant, pH adjuster, preservative, ultraviolet light protector, skin conditioner, solvent or surfactant, as well as anticaking, anti-foaming, antistatic, bulking, emulsifying, opacifying or viscosity decreasing agents. However, a number of the ingredients in these products may act as allergens, carcinogens, endocrine disruptors, immunosuppressants, irritants, mutagens, toxins and/or tumor promoters, and may damage the ocular surface and adnexa.

In addition, there are numerous cosmetic procedures for the eye, including eyelash curling, dyeing, tinting, and perming, botulinum toxin, filler and platelet-rich plasma injections, chemical peels, conjunctival tattooing, eyelid piercing and tattooing, microdermabrasion, microneedling, and skin resurfacing and tightening. A number of these procedures may also be associated with adverse ocular events.

This Cosmetics Subcommittee report examined the use of eye cosmetic products and procedures and how this represents a lifestyle challenge that may exacerbate or promote the development of ocular surface and adnexal disease. Multiple aspects of eye cosmetics were addressed, including their history and market value, psychological and social impacts, possible problems associated with cosmetic ingredients, products, and procedures, and regulations for eye cosmetic use. In addition, a systematic review was included that critically appraises randomized controlled trial evidence concerning the ocular effects of eyelash growth products.

The *TFOS Lifestyle: Impact of cosmetics on the ocular surface* report also highlighted the evidence gaps, indicating directions for future research, and recommendations that ocular cosmetics sold commercially provide information about the concentrations of all chemical ingredients, as well as the product's function, toxicity, indications, contraindications, durability and expiration date [8]. Further, the report recommended:

- conduct of well-controlled and high-quality studies to examine the acute and chronic effects of eye cosmetic ingredients and procedures on the ocular surface and adnexa;
- development of guidelines to assess the safety and tolerability of eye cosmetic products;
- determination of the influence of layered cosmetics and multiple preservatives on periocular skin, especially after long-term use;
- sharing of data publicly for adverse events associated with eye cosmetic product and procedure treatments in aesthetic settings;
- establishment of more stringent and rigorous oversight of the eye makeup industry in general, and eye cosmetic ingredients in particular;
- development of standardized and universally accepted definitions of the words "natural" and "clean," as they relate to cosmetics;
- creation of evidence-based substitution lists of safe ingredients to replace possible toxic compounds in eye cosmetics;
- education of eye care providers and consumers about the risks associated with ingredients within eye cosmetic products.

Ten eye makeup ingredients that may have very significant adverse effects on the ocular surface and adnexa are listed in Table 2.

Table 2
Ten eye makeup ingredients that risk significant adverse effects on the ocular surface and/or adnexa [8].

Ingredient	Products	Concerns
Benzalkonium chloride	eyeliner, makeup remover, mascara	toxic, allergen, irritant
Chlorphenesin	around-eye cream, eyeliner, eyeshadow, eyelash glue, makeup primer, makeup remover, mascara, moisturizer, serum	toxic, allergen, irritant, immunosuppressant
Formaldehyde-releasing compounds	serum, eyelash glue	toxic, mutagen, carcinogen and allergen
Parabens	moisturizer, mascara, eyeshadow, eyeliner, around-eye cream, serum, glitter	toxic, endocrine disruptor, allergen, genotoxic
Phenoxyethanol	eyeshadow, moisturizer, mascara, serum, eyeliner, makeup primer, around-eye cream, makeup remover, glitter, eyelash glue	toxic, allergen, irritant
Phthalates	fragrances, makeup remover	cytotoxic, endocrine disruptor, neurotoxic, sleep problems; dibutyl phthalate is banned in Europe
Prostaglandin analogues (for example, isopropyl cloprostenate)	eyelash growth serum	periorbitopathy, periorbital discoloration, hyperemia, pruritis, eyelid ptosis, meibomian gland dysfunction, blepharophimosis, thinning of eyelid skin and orbital fat
Retinoids (Vitamin A metabolites)	serum, around-eye cream, moisturizer, makeup primer, makeup remover, mascara, eyeliner	toxic to meibomian glands
Salicylic acid	around-eye-cream, makeup primer, makeup remover, moisturizer, serum	restricted use in Canada, Europe and Japan, irritant
Tea tree oil (for example, terpinen-4-ol)	eyelash cleanser, eye makeup remover, moisturizer, toner	toxic to human meibomian gland epithelial cells, endocrine disruptor, allergen, may contribute to antibiotic resistance

5. Digital environment [9]

The digital environment is now ubiquitous. It is well established that the blink rate decreases, and partial blinking is more common when using digital screens [10]. However, the terminology associated with the symptomology is variable including computer vision syndrome, visual fatigue and digital eye strain. The *TFOS Lifestyle: Impact of the digital environment on the ocular surface* report [9] identified a high reported prevalence, from nearly one third to almost all of some populations, but the diagnostic questionnaires used are not specific to symptoms experienced nor exacerbated by the digital environment. In addition, these questionnaires assess the frequency and/or severity of the symptoms, and as little as a single symptom has been considered 'diagnostic'. Objective signs that have been associated with digital eye strain, such as changes in blink rate and critical flicker frequency, have not been found

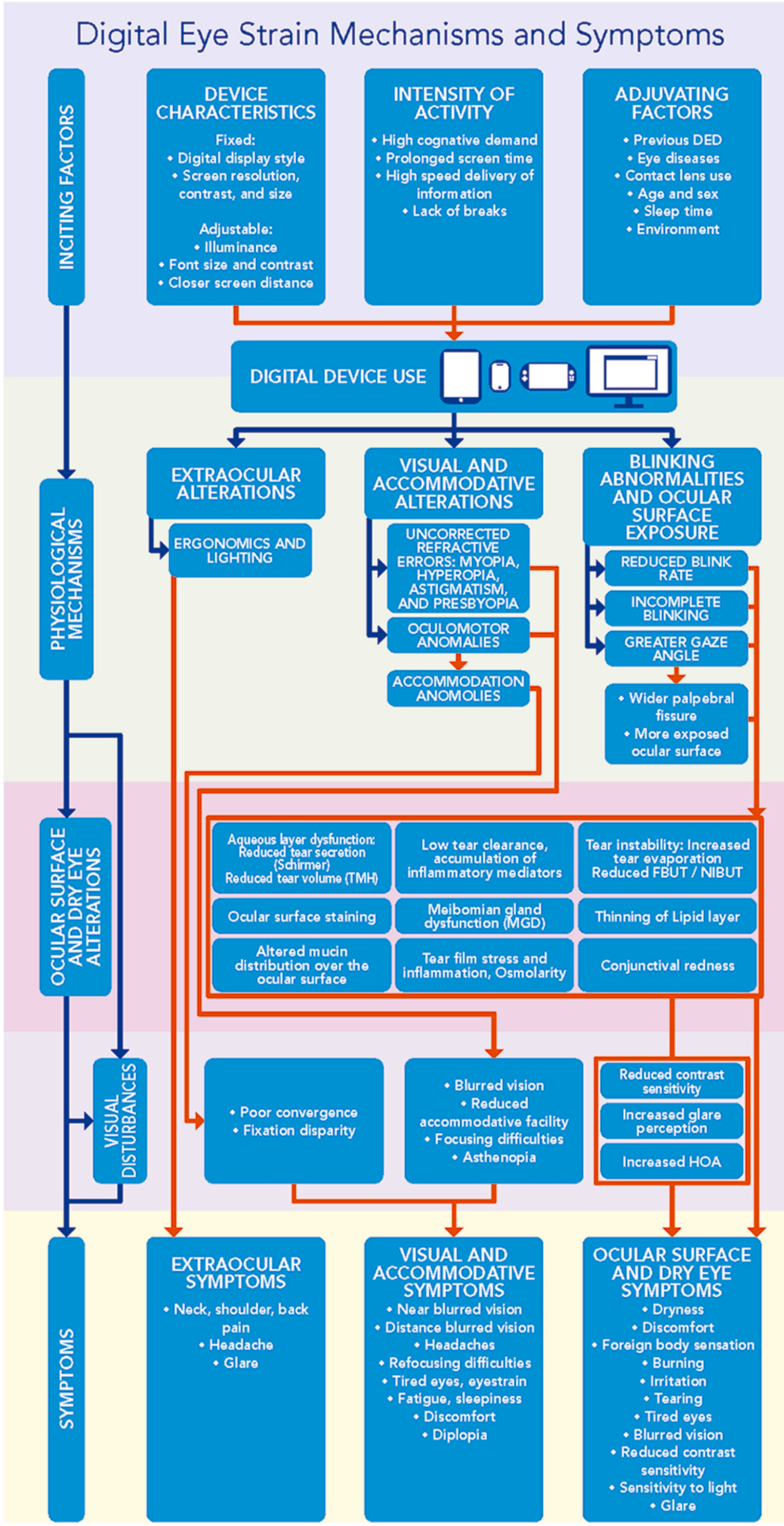


Fig. 3. Proposed mechanisms and symptoms of digital eye strain [9].

to differentiate those reporting symptoms and thus are not 'diagnostic'. A review of the literature identified inciting factors as being the device characteristics (fixed: display style, screen resolution, contrast and size; adjustable: illuminance, font size and contrast and screen distance), intensity of the activity (high cognitive demand, prolonged screen time and lack of breaks) and adjuvating factors (existing dry eye disease, eye disease, contact lens use, age, sex, sleep duration and the environment). The mechanisms can be attributed to extraocular alterations (ergonomics, and lighting), visual and accommodative alterations (suboptimal refractive error and oculomotor abnormalities) and blinking abnormalities/ocular surface exposure (reduced blink rate and completeness, along with a greater gaze angle) compared to an equivalent non-digital task. This causes ocular surface and tear film alterations, visual disturbances (such as blurred vision, compromised binocular vision, reduced contrast, increased glare perception and increased higher order aberrations), leading to symptoms (Fig. 3).

The report recommended that digital eye strain (the preferred terminology) be defined as "the development or exacerbation of recurrent ocular symptoms and/or signs related specifically to digital device screen viewing". Hence it needs to be confirmed that symptoms occur or are exacerbated in a digital environment for a diagnosis to be made. A differential diagnosis should be performed to exclude conditions that could cause similar symptoms such as allergy and infection. Assessment should include the tear film, binocular vision and refraction to determine whether dry eye management, oculomotor exercises or a full refractive correction (respectively) are warranted. If digital eye strain continues to occur, the systematic review identified that oral omega-3 fatty acid supplementation is the only management option with a reasonable level of high quality evidence suggesting its effectiveness; refractive correction appropriate to the screen distance, blink and break regular reminders, ergonomic interventions (avoiding screen reflections and positioning the screen lower than the eyes), device choice (larger

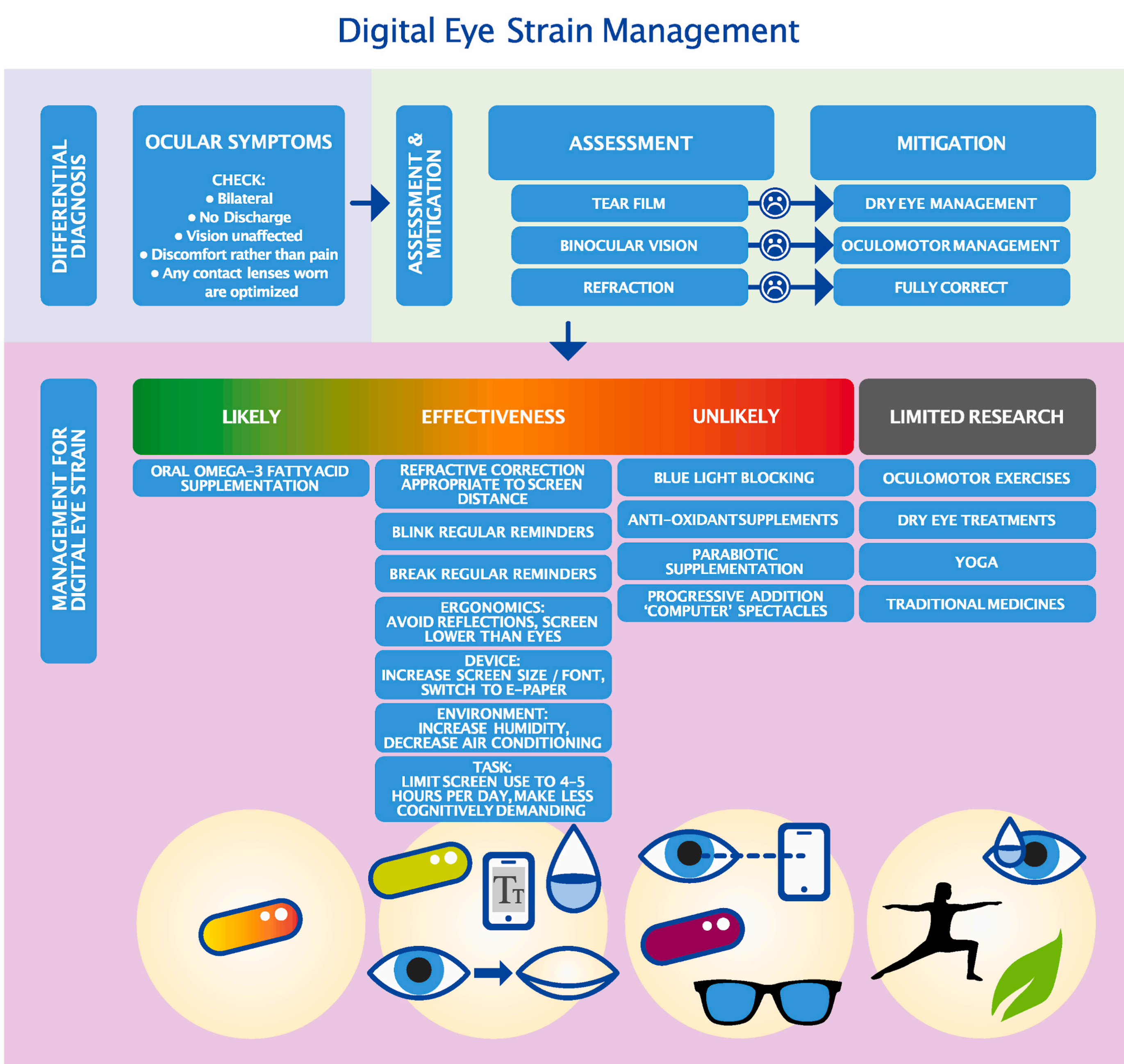


Fig. 4. Management of digital eye strain [9].

screen size/font or switching to e-paper), environmental adjustments (increasing humidity or decreasing air conditioning) and task factors (limiting screen use to 4–5 h a day and reducing the task cognitive demand) are probably effective while there is sufficient research to suggest that blue light-blocking spectacles, anti-oxidant supplements, parabiotic supplementation and progressive addition 'computer' spectacles are unlikely to be effective (Fig. 4).

6. Elective medications and procedures [11]

Aside from a medical indication, patients can choose to use medications or undergo procedures to maintain a healthy state and improve their quality of life. The term 'elective' in the medical field is defined as intervention that is planned or undertaken by choice with a lower grade of prioritization. However, those interventions locally or systemically can affect the homeostasis of the tear film and ocular surface, generating signs and symptoms that could impair the patients' quality of life.

The report evaluated the anatomical and biological impact of elective medications and procedures on ocular surface homeostasis and the potential pathological conditions such interventions trigger. It included a narrative review divided into topical ocular and periocular medications, systemic medications, and elective procedures of the eyelids and periorbital region, conjunctiva, cornea, lens, and other surgeries. It also summarized the neurosensorial consequences on the ocular surface, proposed areas for future research, and increased awareness of patient choice when considering these options.

Several topical (e.g. artificial tears, anti-allergic eye drops, vasoconstrictors, non-steroidal anti-inflammatory drugs, and alternative medicines) and periocular (e.g. eyelid hygiene products, sunscreen, and acne and rosacea creams and ointments) medications and formulations (e.g., those containing BAK or other topical preservatives), exert immuno-inflammatory effects on the cornea, conjunctiva, meibomian glands, and corneal nerves (Table 3).

Elective systemic medications such as corticosteroids and non-steroidal anti-inflammatory drugs, antimicrobials, antihistamines, antidepressants, hormonal replacement, anti-androgens, anabolic steroids, medicines for acne and rosacea and many others can also affect the ocular surface components through different mechanisms, including effects on innervation, vascularity, tissue metaplasia, inflammation, and neurosensory components of target organs (Table 3).

Periocular cosmetic surgery such as blepharoplasty can affect the ocular surface and tear film depending on the eyelid position, surgical technique, amount of tissue removed, and preoperative risk factors (Table 4). Periocular procedures such as botulinum toxin application, cosmetic lasers, and acupuncture show reasonable patient satisfaction and safety profiles. However, adverse effects have been reported on the ocular surface. Care should be taken during treatments to protect the eyes and periocular skin, moderating energy applied as appropriate to decrease adverse side effects.

Ophthalmic surgical procedures also can induce ocular surface disorders (Table 4). Conjunctival surgery, such as excision of pterygia or eye whitening, can lead to iatrogenic dry eye disease, inflammation, and the formation of scars that might compromise the ocular surface. Ocular surface disorders are also common after corneal transplantation, cross-linking, and tattooing and in the early postoperative period after refractive lens surgery.

Dry eye disease frequently occurs after corneal refractive procedures such as laser-assisted *in situ* keratomileusis (LASIK) and photorefractive keratectomy (PRK), primarily attributed to corneal nerve injury, reduced tear secretion, decreased blinking, and medicamentosa. Compared with LASIK, small incision lenticule extraction (SMILE) does not require the creation of a flap and therefore induces less damage to corneal nerves [12].

Elective medications and procedures can compromise the innervation of the ocular surface, jeopardizing its anatomical and functional integrity. Clinically, this can result in ocular surface diseases and chronic pain due to inflammatory or neuropathic etiology or neurotrophic keratopathy. Treating corneal neuralgia is challenging since it involves local and systemic neuronal interactions. As for neurotrophic keratopathy, treatment aims to stimulate epithelial healing, prevent the progression of stromal thinning, and induce corneal nerve growth.

As the cosmetic and refractive surgery industry continues to expand worldwide, the collection of evidence-based information regarding patient outcomes should be used to inform management. Similarly, screening for perioperative risk factors would significantly reduce the risk of developing persistent adverse reactions. It is important to stress

Table 3
Elective topical and systemic medications and devices and reported adverse events on the ocular surface [11].

	Target tissue	Types	Reported adverse events on the OS
Topical medication	**Ophthalmic**	Artificial tears, gels, ointments Complementary and alternative meds Anti-allergic eye drops Alpha-adrenergic agonists (vasoconstrictors) NSAIDs	Allergic reactions Conjunctival hyperemia Dysgeusia DED Follicular conjunctivitis Rebound hyperemia, tachyphylaxis *(alpha-adrenergic vasoconstrictors)* Contact dermatitis Corneal melt *(NSAIDs in compromised corneas)*
	Periocular	Eyelid hygiene products Sunscreen Steroid ointments Ivermectin Acne medication (e.g. acids, retinoids)	DED MGD Epithelial keratitis Conjunctival inflammation Hypersensitivity reactions ↑ IOP *(steroid responder)*
Systemic medication		Corticosteroids NSAIDs Antimicrobials Omega 6 Vitamin supplements Hormonal replacement Anti-androgens Tamsulosin Antihistamines/anticholinergic drugs Medication for acne/rosacea (e.g. Isotretinoin) Antidepressants and anxiolytics	DED MGD Conjunctival inflammation Corneal neuropathy *(vit. B6)* Epithelial keratitis SJS/TEN with OS sequelae *(NSAIDs and antimicrobials)*

Key: OS=Ocular surface; NSAIDs = Non-steroidal anti-inflammatory drugs; DED = Dry eye disease; MGD = Meibomian gland dysfunction; IOP=Intraocular pressure; SJS/TEN=Stevens-Johnson syndrome/Toxic epidermal necrolysis.

Table 4
Elective ophthalmic and non-ophthalmic surgical and non-surgical procedures and reported adverse events on the ocular surface [11].

	Target tissue	Types	Reported adverse events on the OS
Ophthalmic surgical procedures	**Lids and periorbital**	Blepharoplasty Ptosis Canthoplasty Brow surgery	Corneal abrasion Lacrimal gland injury Chemosis Eyelid malposition (lagophthalmos, lower lid retraction, ectropion), Granuloma Infection Scarring
	Conjunctiva	Pterygium and Pinguecula Conjunctivochalasis Benign tumor resection (e.g. naevi) Eye whitening	DED Granuloma Conjunctival inflammation Chemosis Conjunctival hemorrhage Scar formation Scleral complications
	Cornea	Keratorefractive surgery LASIK PRK SMILE ICRS Corneal inlays Corneal cross-linking Cosmetic keratoplasty Phototherapeutic keratectomy Corneal tattooing	DED MGD Infection Epithelial keratitis Corneal erosions Corneal haze Corneal melting Corneal toxicity Neurotrophic keratitis Neuropathic pain
	Lens and anterior and posterior chamber	Phacorefractive surgery Phakic intraocular lens	DED MGD Infection Epithelial keratitis Corneal erosions Neurotrophic keratitis Neuropathic pain
Non-ophthalmic surgical procedures		Neurosurgical procedures Bariatric surgery Radiation therapy	DED Neurotrophic keratitis
Non-surgical ophthalmic procedures and devices		Cosmetic Lasers Intense pulsed light therapy Botulinum toxin Punctal occlusion Acupuncture and Moxibustion	Ectropion and skin complications Conjunctival hyperemia Corneal injuries Temporary scleral show/ lagophthalmos Granuloma Canaliculitis Dacrocystitis, Toxic tear syndrome *(Punctal occlusion)* Globe penetration *(Acupuncture)* Burns *(Moxibustion)*

Key: OS=Ocular surface; DED = Dry eye disease; MGD = Meibomian gland dysfunction; LASIK=Laser-assisted *in situ* keratomileusis; PRK= Photorefractive keratectomy; SMILE=Small incision lenticule extraction; ICRS=Intracorneal ring segments.

that increasing awareness of the potential risks, benefits, and consequences can help patients make the right decisions when considering elective procedures and medications.

7. Environmental conditions [13]

The environment comprises a broad range of conditions in constant and direct contact with the ocular surface. Environmental conditions encompass climate factors (e.g., sunlight, temperature, humidity), pollutants (e.g., particulate matter, aerosols) and allergens (indoor and outdoor) (Fig. 5). These conditions are concurrent and not mutually exclusive, with constant interchange between environmental components and properties, and broader pathways of exposure.

The narrative component of this Subcommittee report provided an overview of the risk factors and ocular surface diseases associated with different environmental exposures. Regarding climate factors, temperature is associated with dry eye disease, trachoma and allergic conjunctivitis; low humidity negatively correlates with dry eye disease and allergic and adenovirus conjunctivitis; altitude increases the risk for pterygium and dry eye disease; and ultraviolet radiation can cause pterygium, neoplastic ocular surface disease and climatic droplet keratopathy. Extreme weather conditions, increasing temperatures and precipitation drive longer pollen seasons and higher concentrations of indoor and outdoor allergens and allergic conjunctivitis occurrence. Air pollution is the mixture of toxic chemicals or compounds such as gases and particulate matter from natural and manmade sources, and large population-based studies have shown a correlation between dry eye disease and conjunctivitis with such pollution. Volcanic ash can cause keratoconjunctival foreign bodies and eye irritation, but not chronic or visually disabling ocular adverse effects. Dust exposure may precipitate dry eye disease and conjunctivitis. Other risk factors such as the use of masks in the COVID-19 pandemic, exposure to biochemicals, bioterrorism and smoking are also recognized in other Subcommittee reports.

Ocular surface diseases are multifactorial conditions and frequently more than one environmental factor is associated with the same disease. Several environmental risk factors are associated with dry eye disease such as pollution from both urban outdoor and indoor settings, low humidity, temperature variations and wind speed. Acute episodic flares are associated with environmental stresses showing a rapid exacerbation of ocular discomfort and inflammation. Risk factors associated with higher prevalence of ocular allergy include climate-related factors such as high environmental temperature and low humidity, exposure to mold/dampness, dust particles and cigarette smoke, close household animal contact in childhood and a parental history of atopic disease. The general population prevalence of pterygium (10–12%) is higher at lower latitudes and especially in equatorial regions. Important environmental risk factors associated with pterygium are prolonged sunlight exposure, high altitude and outdoor work. Climatic droplet keratopathy is related to intense constant winds, low humidity and high ultraviolet exposure, in hot or cold arid climates, such that this degeneration is considered a rural and outdoor disease often affecting Indigenous peoples in the Americas. The most important environmental predisposing factors associated with ocular surface neoplasia are chronic solar radiation exposure and cigarette smoke exposure. Ocular surface injuries may occur from accidental contact with chemicals, such as in industrial environments, construction areas (alcanine), farms work (pesticides), alkali assaults, methamphetamine labs, pepper spray attacks and household activities. Thermal injuries may be caused by direct flames, scalding liquid, or burning hot items such as cigarettes and fireworks.

Climate change is reflected in the frequency and severity of extreme weather events, such as heat, drought, and heavy rain. These changes can alter the pattern distribution and burden of water and airborne vectors, and indirectly influence ocular surface health through impacts on nutrition, mental health, violence and conflict around the world.

The systematic review within this report addressed the key question: "What are the associations between outdoor environment pollution and dry eye disease symptoms and signs in humans?" and found that dry eye disease increased with air pollution (from nitrogen dioxide and carbon monoxide) and soil pollution (from chromium), but not with air pollution from particulate matter.

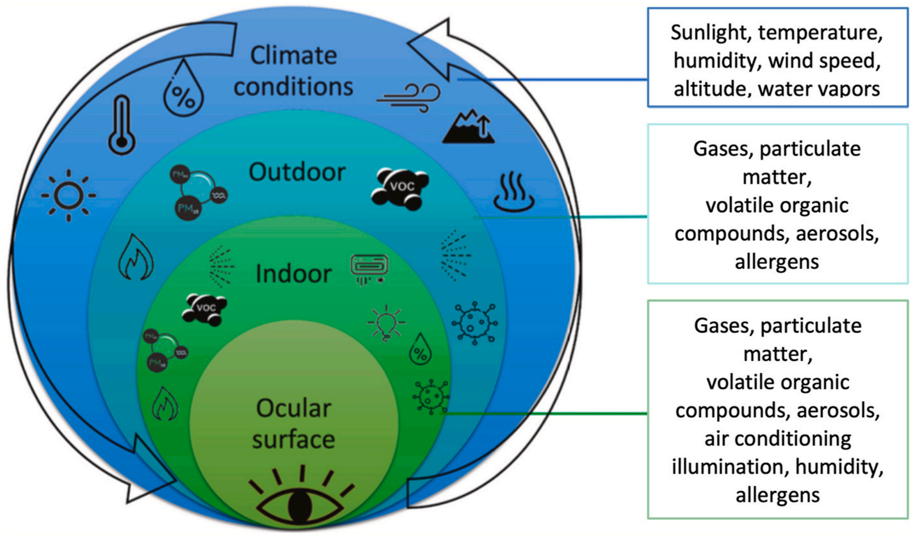


Fig. 5. Environmental conditions: climate factors and pollutants [13].

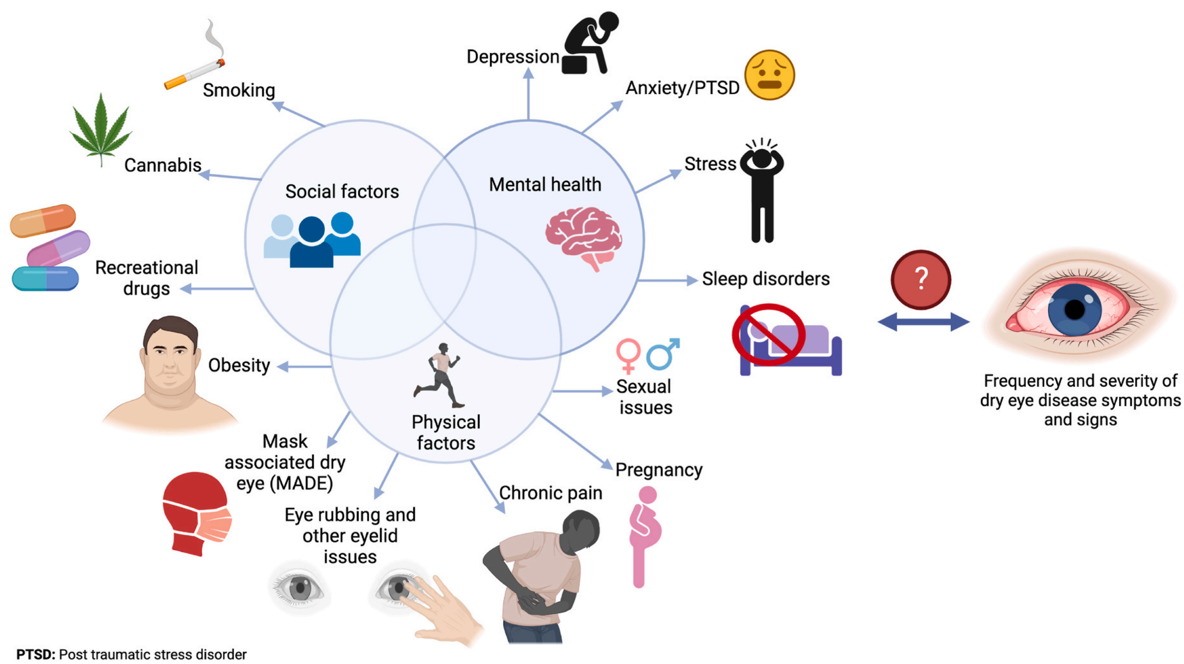


Fig. 6. Multiple daily life decisions associated with lifestyle can induce or modulate the severity of symptoms and signs of dry eye disease and other ocular surface diseases [14].

8. Lifestyle challenges [14]

Many factors in the domains of mental, physical, and social health have been associated with various ocular surface diseases, with most of the focus centered on aspects of dry eye disease (Fig. 6).

Regarding mental health factors, several cross-sectional studies have noted associations between depression and anxiety, and the medications used to treat these disorders, and dry eye disease symptoms. Sleep disorders (involving both quality and quantity of sleep) have also been associated with dry eye disease symptoms (Fig. 7). Under the domain of physical health, several factors have been linked to meibomian gland abnormalities, including obesity and face mask wear. Cross-sectional studies have also linked chronic pain conditions, specifically migraine, chronic pain syndrome and fibromyalgia, to dry eye disease symptoms more than to signs.

A systematic review and meta-analysis reviewed available data and concluded that various chronic pain conditions increase the risk of dry eye disease (variably defined), with odds ratios ranging from 1.60 to 2.16. However, heterogeneity was noted, highlighting the need for additional studies examining the impact of chronic pain on dry eye disease signs and subtype (evaporative versus aqueous deficient). With respect to societal factors, tobacco use has been most closely linked to tear film instability, cocaine to decreased corneal sensitivity, and alcohol to tear film disturbances and dry eye disease symptoms.

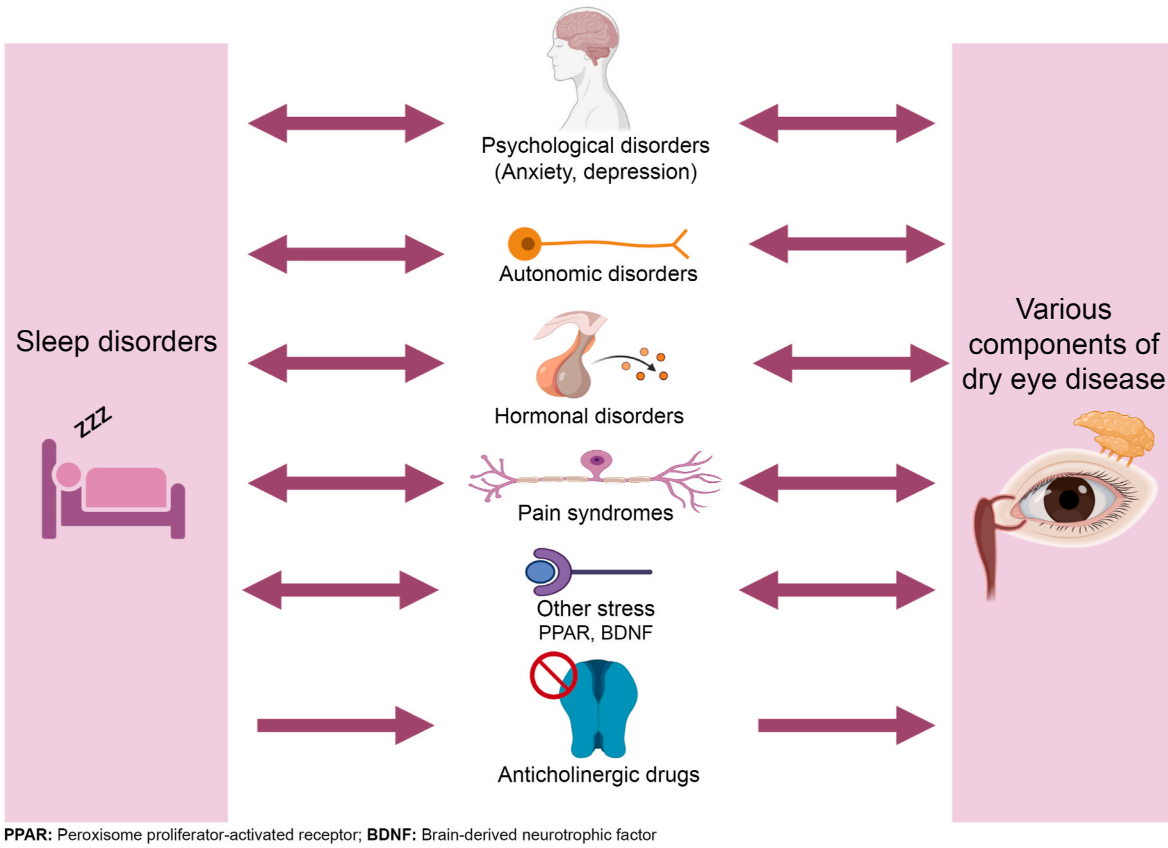


Fig. 7. Potential mechanisms underlying the association between sleep disorders and dry eye disease symptoms and signs [14].

9. Nutrition [15]

Nutrition is a modifiable, core part of our lifestyle that can influence general health and well-being. As the prevalence of nutrition-related chronic diseases climbs, it is imperative that the effect of nutrition on the ocular surface, either directly or because of the chronic diseases that result, is understood.

With regard to macronutrients, evidence that omega-3 deficiency results in ocular surface sequelae is provided in accumulating (though sometimes conflicting) evidence. Direct evidence, however, is lacking for the role of oils such as olive oil, primrose oil, palm oil, soybean oil and hydrogenated vegetable oils. Sugars and artificial sweeteners, while being shown to be involved in metabolic syndrome and glucose intolerance, have not yet been studied directly with regard to the ocular surface. Regarding micronutrients, the major vitamins identified to play a role in ocular surface health are vitamins A, B_{12}, C and D.

Of the dietary supplements reviewed, omega-3 and omega-6 polyunsaturated fatty acids are the most extensively studied in ocular surface disease. Given the current evidence of efficacy and their relatively favorable safety profile, omega-3 fatty acids may be a relevant treatment option for patients with dry eye disease and meibomian gland dysfunction.

Hydration is essential for the optimal function of the human body, however, to date there have been few studies that assessed the role of hydration status or water intake on ocular surface health. Future longitudinal studies should investigate whether increasing water intake is beneficial in patients with dry eye disease.

An area of increasing interest is that of the role of excipients, additives and non-nutritional components on health. Further studies on the role of the many endocrine-disrupting chemicals on ocular surface disease are clearly needed, as well as the possible effects of food additives and non-nutritional chemicals, such as nanoparticles, emulsifiers and flavor enhancers, including glutaminase and monosodium glutamate, with most studies to date being directed towards understanding their impact on systemic health and the gut microbiome.

There is a paucity of data on the effect of different diets, with the effect of a high-fat diet, reflective of the Western diet, being explored largely in animal models. The Mediterranean diet is the most studied, with a number of studies providing some evidence regarding its beneficial effect on dry eye disease.

The Subcommittee undertook a systematic review and meta-analysis to evaluate the effects of intentional food restriction on the ocular surface, concluding that there was a lack of high-quality evidence assessing this question to date. Mixed results were reported in individual studies in relation to the effects of religious fasting and bariatric surgery on traditional measures of ocular surface health (e.g., dry eye symptoms, tear film breakup time and Schirmer score).

Investigations into the gut microbiome and the ocular surface have been limited in size and sporadic, and additional research in this area is needed. There is little evidence currently to state definitively that modulation of the gut microbiome has beneficial effects on the ocular surface. Many metabolic and gastrointestinal disorders have been associated with an increased risk of ocular surface disease. Although the exact pathophysiological pathways leading to comorbid ocular surface diseases are often unknown for these disorders, the disorders may lead to deficiencies of micro- and macronutrients that are important in maintaining ocular surface health. With respect to cancer, most potential impacts on the ocular surface are likely to be overshadowed by the side-effects of chemotherapy.

Good nutrition is clearly pivotal to good health. There is substantial evidence that good nutrition also impacts the ocular surface (Fig. 8).

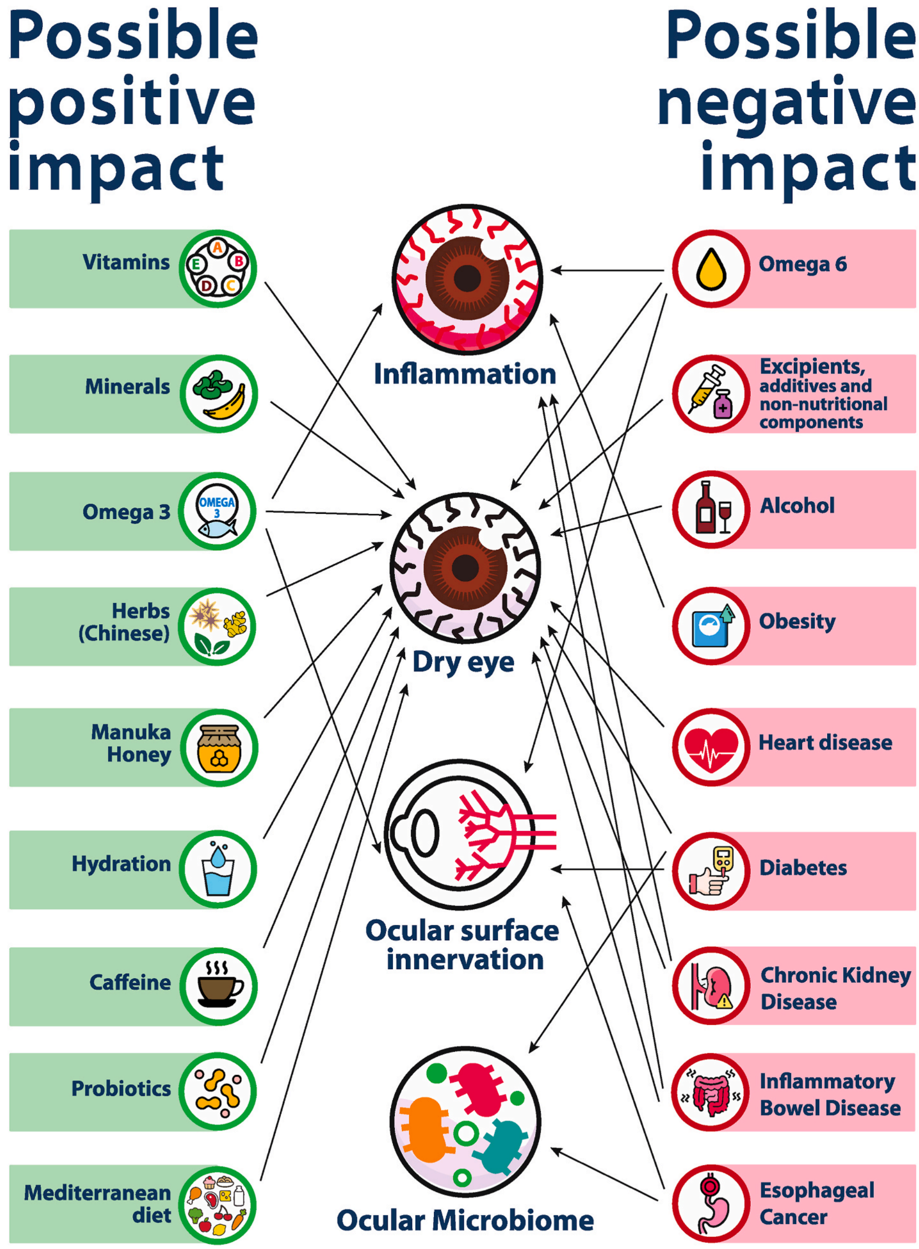


Fig. 8. Impact of nutrition on the ocular surface [15].

10. Societal challenges [16]

The prevalence and severity of both acute and chronic ocular surface diseases are influenced directly and through interactions between individual, social, cultural, regional and global factors, which underpin population health. The overlay of the digital environment, natural disasters, conflict and the pandemic have modified access to services in some regions.

While the impact of age, race and biological factors on many ocular surface diseases are well established, the effects of sex may be confounded by other social or gender constructs including access to health care, employment, poverty and education. In addition, differences in rate of disease in different populations (e.g., Indigenous versus non-Indigenous) may be confounded by broader societal issues such as access to health care resources, poverty, education and disadvantage/marginalization.

Individual choices, social or lifestyle factors include those with both positive and negative effects on ocular surface diseases, such as exercise, recreational drug use, hobbies, traditional medicines and the effects of societal supports or societal pressures. The relative impact of these factors is closely related to regional and socioeconomic variations.

Living and working conditions can significantly impact ocular surface diseases. The type of occupation may clearly predispose to certain injuries or diseases, however, the morbidity of these conditions is strongly influenced by poverty, (childhood) education, water and sanitation, housing and socioeconomic factors.

Regional and global socioeconomic, cultural and environmental conditions relevant to ocular surface diseases include the impact of remoteness to treatment, the change in the spectrum of disease with seasonality or climate variations, availability and affordability of eye care services and accessibility of culturally appropriate services. The effects of climate change on water quality, access to services and food security may influence the type and severity of ocular surface diseases. Gendered violence, conflict, and mass immigration challenge financial and food security, and may limit access to care. During wartime or conflict, decreased personal security, inadequate access to health

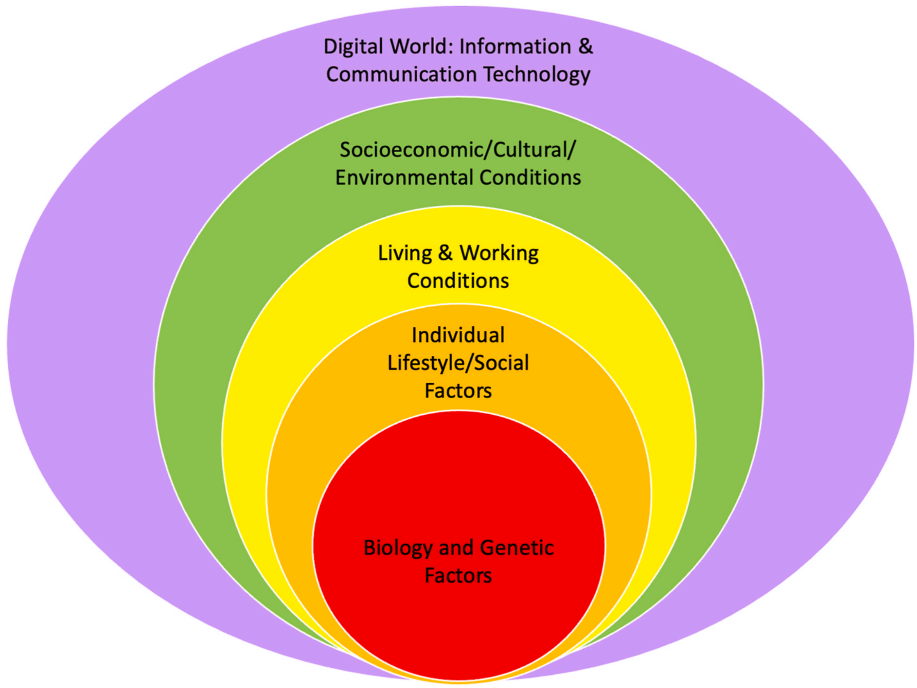


Fig. 9. The framework used in creating the *TFOS Lifestyle: Impact of societal challenges on the ocular surface* report [16], modified from Rice and Sara [17].

services in general, and the absence of health workers reduces the ability to access eye care services and diseases of the ocular surface are not prioritized in these situations.

In the information technology era, health communication patterns have changed and patient- and practitioner-specific issues impact both access to, and the different types of eye care services available. The impact of the digital environment on physical, mental and social health includes the effect of social isolation on both the risk and severity of ocular surface diseases.

The impacts of the pandemic on ocular surfaces diseases through effects on mental health, access to services, face mask and hand sanitizer use and changes to the work environment were considered. Such impacts were more marked in groups with greater societal disadvantage. Through systematic review it was established that the COVID-19 pandemic and the various mitigating strategies or their consequences, including increased screen time and online learning were associated with an increased risk of developing new or worsening pre-existing ocular surface diseases. Given the longer-term changes in remote or flexible work and study practices observed beyond the immediate pandemic period, it seems reasonable to assume that increased frequency and severity of these conditions will persist.

This report exposed social determinants of health, interconnecting in their influence on disease, rather than causing the disease, which should encourage the development of more comprehensive initiatives and a whole-of-society approach. The framework used in creating this report is shown in Fig. 9.

11. Conclusion

Unintended consequences that threaten ocular surface health can arise as a result of lifestyle choices made by patients. The *TFOS Lifestyle Workshop* report provides a comprehensive review of the literature on the direct and indirect impacts of a wide range of lifestyle choices and challenges on the ocular surface and identifies current gaps in knowledge. Outcomes point to the importance of lifestyle consideration in patient management and in seeking disease prevention strategies, to optimize quality of life and reduce the burden of ocular surface disease.

Dedication

The *TFOS Lifestyle Workshop* report is dedicated to the late Dr. Juan Carlos Abad (Department of Ophthalmology, Antioquia Ophthalmology Clinic-Clofan, Medellin, Antioquia, Colombia), in recognition of his outstanding scientific contributions to the fields of the ocular surface, tear film and keratoprosthesis. Juan Carlos, who served on the Societal Challenges Subcommittee, was a visionary, a TFOS Ambassador, and an extraordinary clinician.

Disclosures

Jennifer P. Craig: Adelphi Values Ltd (R), Alcon (C,F,R), Asta Supreme (F), Azura Ophthalmics (C,F), BCLA (S), E-Swin (F,R), Johnson & Johnson Vision (R), Manuka Health NZ (F), Medmont International (F), Novoxel (R), Photon Therapeutics (F), Resono Ophthalmic (F), TFOS (S), Théa (F,R), Topcon (F,R), TRG Natural Pharmaceuticals (F).

Monica Alves: FAPESP (F), FAEPEX (F), Alcon (C,F), Allergan/Abbvie (C,F), Latinofarma (C,F), TFOS (S), Uniaoquimica (C,F)

Laura E. Downie: Alcon (F), Azura Ophthalmics (F), BCLA (R), CooperVision (F), Cornea and Contact Lens Society of Australia (R), Medmont International (F), Novartis (F), TFOS (S)

Nathan Efron: Clinical & Experimental Optometry (S), CooperVision (R), Elsevier (R)

Anat Galor: AstraZenica (C), Dompé (C), EyeCool (C), Novaliq (C), Novartis (C), Oyster Point Pharma (C), Tarsus (C)

José Alvaro Pereira Gomes: Alcon (C,F,R), Allergan/Abbvie (R), Bausch + Lomb (C), CAPES (F), Cnpq (F), FAPESP (F), Johnson & Johnson Vision (C,R), Latinofarma/Cristália (C,R), Novartis (C), Ofta Vision Health/EMS (C,R), Ophthalmos (C)

Lyndon Jones: Alcon (F,C,R), Azura Ophthalmics (F), Bausch + Lomb (F), CooperVision (F,C,R), Essilor (F), Hoya (F), I-Med Pharma (F), ISCLR (S), Johnson & Johnson Vision (F,C,R), Menicon (F,R), Novartis (F), Ophtecs (F,C,R), Ote Pharma (F), Santen (F), SightGlass (F), SightSage (F), TFOS (S), Topcon (F), Visioneering Tech (F)

Maria Markoulli: Alcon (C,F,R), Bausch + Lomb (R), BCLA (S), Clinical and Experimental Optometry (S), CooperVision (F), CSL Sequiris (R), TFOS (S)

Fiona Stapleton: Alcon (C,F), Allergan (F), ANZ Childhood Myopia Group (S), Azura Ophthalmics (F), Brien Holden Foundation (S), Coopervision (F,R), CSL Seqirus (C,R), Exonate (F), Future Vision Foundation (S), ISLCR (S), Menicon (F,R), Novartis (C,F), Nthalmic (F), Sun Pharmaceuticals (C)

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Amy Gallant Sullivan: TFOS Executive Director (S), Essiri Labs (I), Lμbris BioPharma (I)

David A. Sullivan: Essiri Labs (I), Institute of Eye Surgery (R), Lμbris BioPharma (I, P), TFOS (S)

Mark D. P. Willcox: Allergan (F), American Society for Microbiology (S), ISCLR (S), Lumicare Pty Ltd (C), Modulation (F), MUVi (F), Ophtecs (C, R), San Air (F), TFOS (S), Whiteley Corp (F)

James S. Wolffsohn: 3 M (F), Alcon (C,R), Allergan (F), Amplivox (F), AOS (C), Aston Vision Sciences (I), Atia Vision (C), Bausch + Lomb (C), BCLA (S), Body Doctor (F), CooperVision (C), Dopavision (C), Eyoto (I), Johnson & Johnson Vision (F), MC2 Pharmaceuticals (F), Medmont (C), Novartis (F), NuVision (C,F), Rayner (F), Santen (C), SightGlass (C, F), Théa (C,F), Topcon (F), TFOS (S), Veluon (F), Wolffsohn Research Limited (I)

Acknowledgments

All members of the *TFOS Lifestyle Workshop*, are gratefully acknowledged for their contributions to the Workshop process and the subsequent publications. Amy Gallant Sullivan (TFOS Executive Director, France) is gratefully acknowledged for raising the funds that made this initiative possible. The *TFOS Lifestyle Workshop* was supported by unrestricted donations from Alcon, Allergan an AbbVie Company, Bausch+Lomb, Bruder Healthcare, CooperVision, CSL Seqirus, Dompé, ESSIRI Labs, ESW-Vision, Eye Drop Shop, I-MED Pharma, KALA Pharmaceuticals, Laboratoires Théa, Santen, Novartis, Shenyang Sinqi Pharmaceutical, Sun Pharmaceutical Industries, Tarsus Pharmaceuticals, Trukera Medical and URSAPHARM.

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