SCREENS AND OUR EYES

THE STRAIN IS A GLOBAL ONE

plano

Anglia Ruskin University | School of Medicine

Authored by: Arief Tjitra Salim[1], Joshua Foreman[1], Stuart Keel[1,2], Mohamed Dirani[1,3,4]

Reviewed by: Peter van Wijngaarden[2], Jonathan Guy Crowston[1,3,5], Rupert Bourne[6]

1. Plano Pte Ltd, Singapore
2. Centre for Eye Research Australia (CERA), Ophthalmology, Department of Surgery, University of Melbourne, Australia
3. Singapore Eye Research Institute, Singapore National Eye Centre, Singapore
4. Ophthalmology and Vision Sciences Academic Clinical Program, Duke-National University of Singapore Medical School, Singapore
5. Centre for Vision Research, Duke-National University of Singapore Medical School, Singapore
6. Vision & Eye Research Unit, Postgraduate Medical Institute, Anglia Ruskin University, Cambridge, United Kingdom

CONTENTS

PREFACE

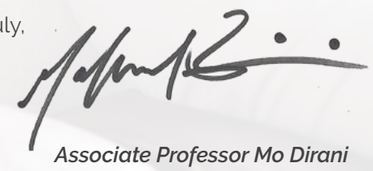
Smart devices have become indispensable tools in our personal, educational and professional lives, and there is no denying the numerous advantages they provide in the form of improved efficiency, access to any information we desire within seconds, and an endless stream of entertainment options. However, despite the obvious benefits provided to us by smart devices, it is important to be aware of the potentially negative consequences when they are used excessively and in the wrong way. For many years, scientific evidence has shown that too much screen time is associated with a range of health problems including diabetes, heart disease, cancer, and mental illness. Recently, a number of important eye conditions have been added to this list, including myopia or short-sightedness and a condition known as digital eye strain.

Digital eye strain is a very common eye condition that includes symptoms of pain, dryness and an inability to focus, and this condition results from spending long periods of time staring at the screens of devices such as computers, smartphones and tablets. It is not surprising then that the prevalence and severity of this condition are increasing as we continue to use smart devices for longer periods of time and with greater frequency.

The personal, societal and economic impact of digital eye strain as well as the other adverse health outcomes associated with excessive device use have been largely ignored and the information available to parents, teachers and professionals whose work-related tasks require extended screen time is scarce and often incomplete. As an eye health research scientist and the founding Managing Director of plano, a company dedicated to developing digital solutions to the problem of excessive device use, I feel a responsibility to both educate the public and provide scientifically-backed solutions to this ever-growing problem. This easy-to-follow report was created to fulfil that goal, and includes information derived from the latest scientific literature as well as an evidence-based guide on how to prevent and manage digital eye strain through behavioural and technological solutions.

I have often said that technology itself is not the problem. Rather, the problem arises from our tendency to form unhealthy, dependent and compulsive relationships with technology, and it is precisely these relationships that need to be addressed if we hope to remedy the smart device public health crisis. Used responsibly, technology can truly enrich our lives and it is therefore critical that technology users are better informed about how to maintain a better tech-life balance so that we can enjoy the fruits of our inventions without the strain of avoidable screen-related health problems.

Yours Truly,



Associate Professor Mo Dirani

EXECUTIVE SUMMARY

The rise and rise of the digital age

Digital screen-based activities permeate every aspect of our lives, with half of all households around the world having a personal computer and up to 35% of people owning a smartphone. It has become obvious that many people, especially children and teenagers, spend increasingly long hours in front of screens, often at the expense of other activities including face-to-face social interaction and educational responsibilities. As more people adopt a digital lifestyle at younger ages and continue to use their devices more often, there is growing interest by researchers, healthcare professionals and the general public regarding whether these long hours spent staring at screens contribute to poor health and, if so, how these negative health outcomes may be avoided.

Is too much screen time bad for your health?

Research is beginning to shed light on the health consequences of excessive screen time, including an increased risk of diabetes, heart disease and cancer, resulting from the sedentary lifestyle associated with device use. Musculoskeletal disorders are very common in people who use devices for long periods of time and may result from the unnatural posture experienced during long hours of device use. Significant disturbances to mental health, including internet addiction disorder, depression and anxiety have also been associated with too much screen time, with many young people experiencing compulsive urges to use their devices, as well as social isolation and strained family relationships. Excessive screen time has also been linked to significant eye health problems, however this issue has been under-investigated.

Screen time and eye health

Excessive screen time has been linked to eye health problems both in children and adults. The ability of the eye to focus on distant objects develops well into teenagerhood and requires extended periods of time outdoors looking at distant objects. When young people spend too much time indoors and staring at near objects, this process may sometimes be disrupted, increasing the risk of short-sightedness or myopia. As many as 80-90% of young people in developed parts of Asia now have myopia, and evidence suggests that excessive screen time is contributing to the worsening of the global myopia epidemic.

Another major and often neglected eye condition associated with excessive device use is digital eye strain (DES) or computer vision syndrome (CVS). This report focuses primarily on DES, including the signs, symptoms, possible causes and management options of this widespread condition.

Digital eye strain

DES is a very common eye disorder, affecting up to 20% of children and as many as 90% of university students. It is also highly prevalent in adults who use computers and device screens professionally and is associated with significant economic and productivity loss, costing just the US economy US$3.84billion annually.

The symptoms of DES include eye irritation, burning, dryness, redness, sensitivity to light and a loss of the eye's ability to focus correctly, resulting in blurred vision and headaches. DES has been linked to screen time, with those spending three or more hours on screens per day being at 13-fold greater risk.

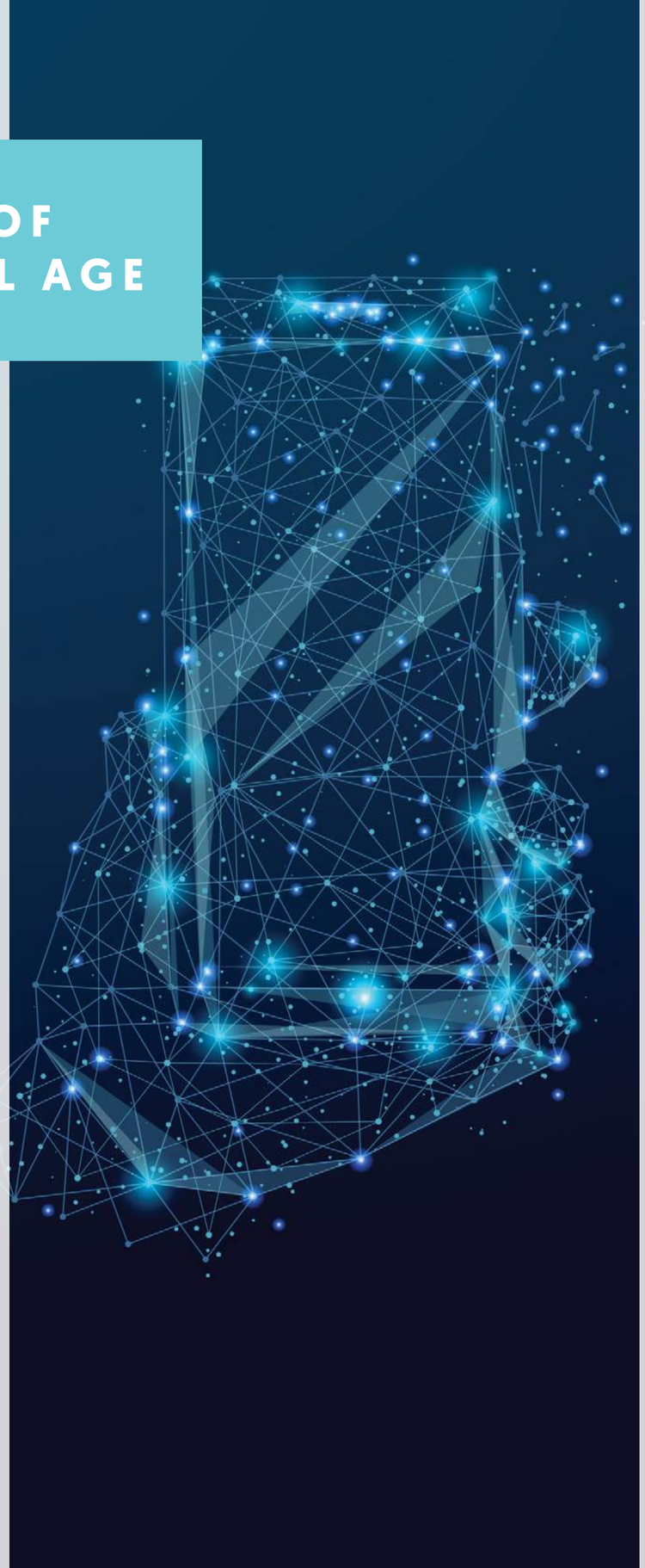
How to manage digital eye strain

DES can be diagnosed and treated by an eye health professional. Treatments include: 1) correction of the eye's refractive or focusing error using a variety of lens types; 2) treating the lenses of glasses with filters and coats to reduce reflection and to block out harmful light; 3) lubricating eye drops and; 4) alternative treatment options including omega-3 fatty acids and blueberry extract. However, treatment of DES is not always effective and prevention through responsible and healthy screen-based behaviours is recommended. These behaviours include: 1) taking regular breaks in between periods of screen exposure; 2) limiting daily screen time and engaging in at least 2-3 hours of outdoor activity per day; 3) increasing text size to reduce eye squinting; 4) reducing overhead lighting and using anti-glare screens; 5) maintaining a good face-to-screen distance; and 6) ensuring screens are not placed above eye-level, preferably 15-20 degrees below eye level.

Introducing plano, the app that is turning the problem into the solution

Without proper guidance and consistent reminders, it is difficult to maintain the abovementioned healthy device-use behaviours. plano is a technological device-based solution that can help you to monitor your own device use as well as that of your children. The functions and features of the plano app were developed to address the problem of unhealthy device use based on science and market research and include: 1) allowing parents to monitor and control their child's device use remotely; 2) remote device locking; 3) blocking malicious applications and browsers; 4) sending prompts to remind users to take regular breaks, look far into the distance and encourage them to spend time outdoors; 5) detecting and monitoring face-to-screen distance and posture, and notifying users to correct their distance and posture when required; 6) providing smart referrals to optometrists for users to ensure timely and regular comprehensive eye tests; 7) sending reports on device use activity and behaviour and; 8) rewarding children who follow the healthy device use guidelines with points so they can send a wish list of family-friendly activities and merchandise to their parents from plano's partner vendors through the plano shop. plano also offers its plano@work service to assist working adults to maintain healthy device use habits through expert talks, staff training on responsible device use and good eye care habits, and evidence-based recommendations to achieve a vision-friendly workplace.

THE RISE AND RISE OF THE MOBILE DIGITAL AGE



Digital technology and its associated conveniences are so pervasive in every aspect of our lives that it is almost inconceivable that we ever lived in a world without them. However, as recently as the early 1990s, most households and many work places did not even have computers. Early computers were large and limited in their capabilities, and their use was initially restricted to industry and research. However, through technological advancements including the development of faster processors and the miniaturisation of computer chips, computers became sophisticated and small enough to be used in the office and the home. With the launch of public access to the internet in 1991 and the ensuing explosive development of new and interesting web content and features that catered to people of all walks of life, the personal computer became an essential component of every household and office.

Until the development of the earliest smartphones in the 1990s, screen-based activities were largely restricted to the home and office due to the need for cable-based power sources and internet access. Due to the limited capabilities of early phones, existing mobile technology was used principally to make phone calls. However, because of technological breakthroughs including wireless internet, increased computing power and high-definition colour screens, the uptake of mobile screen-based devices including phones, laptops and tablets has increased at an exponential rate. While personal computers still play a significant role in people's lives, being present in almost half of homes worldwide,[1] the convenience of being able to stay connected anywhere and at any time has seen smart devices being adopted as the preferred means of digital activity in recent years.[2] Indeed, in 2018, 35% and 17% of the global population were smartphone and tablet owners, respectively, and the proportion of people who own devices is expected to continue to increase significantly.[3, 4]

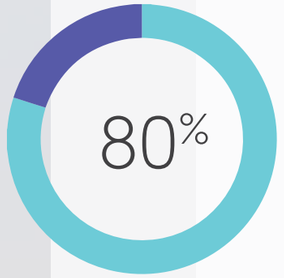
Internet users

147 million in 1998

4+ billion in 2018

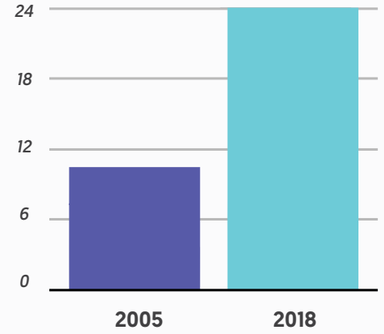
The smart device revolution has contributed to a dramatic increase in the number of internet users globally, with an increase from 147 million (4% of the world's population) in 1998 to over 4 billion (53% of the world's population) in 2018.[2, 5] Recent research has found that internet users currently spend an average of six hours per day on devices which, collectively, is equivalent to the global internet user population spending approximately 1 billion years (8.76 trillion hours) on devices per year.[2]

Americans exposed to 10 hours of screen time per day



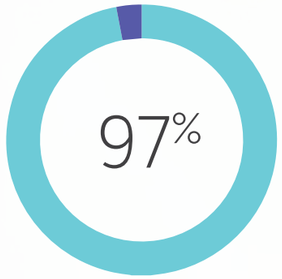
2018

UK citizens' hours of exposure to screen time per week

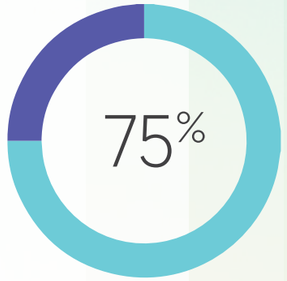


The uptake of screen-based technology has been widespread in people of all ages, but with different patterns of use and consequences amongst different age groups. Approximately 80% of American adults now own a smartphone and are exposed to screens for an average of 10 hours per day.[6, 7] In the United Kingdom, the number of hours that adults spend on their smart devices weekly has more than doubled from 10 hours in 2005 to 24 hours in 2018.[8] The majority of adults use two or three devices simultaneously, reflecting their varied professional and personal obligations.[9] Of particular concern in adults is the tendency for many people to spend long and uninterrupted periods looking at computer screens at work.

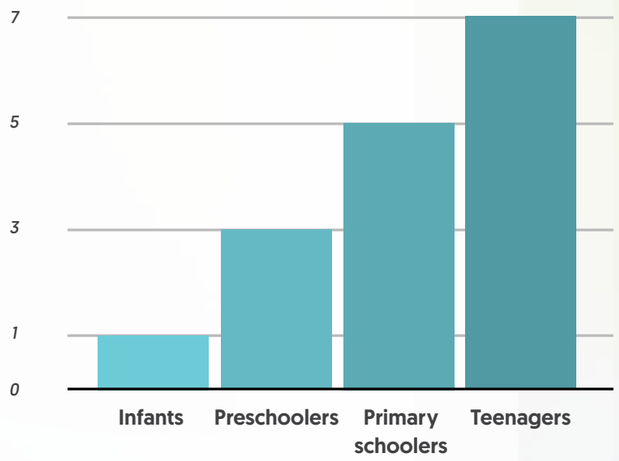
Children 4 years or younger using smart devices



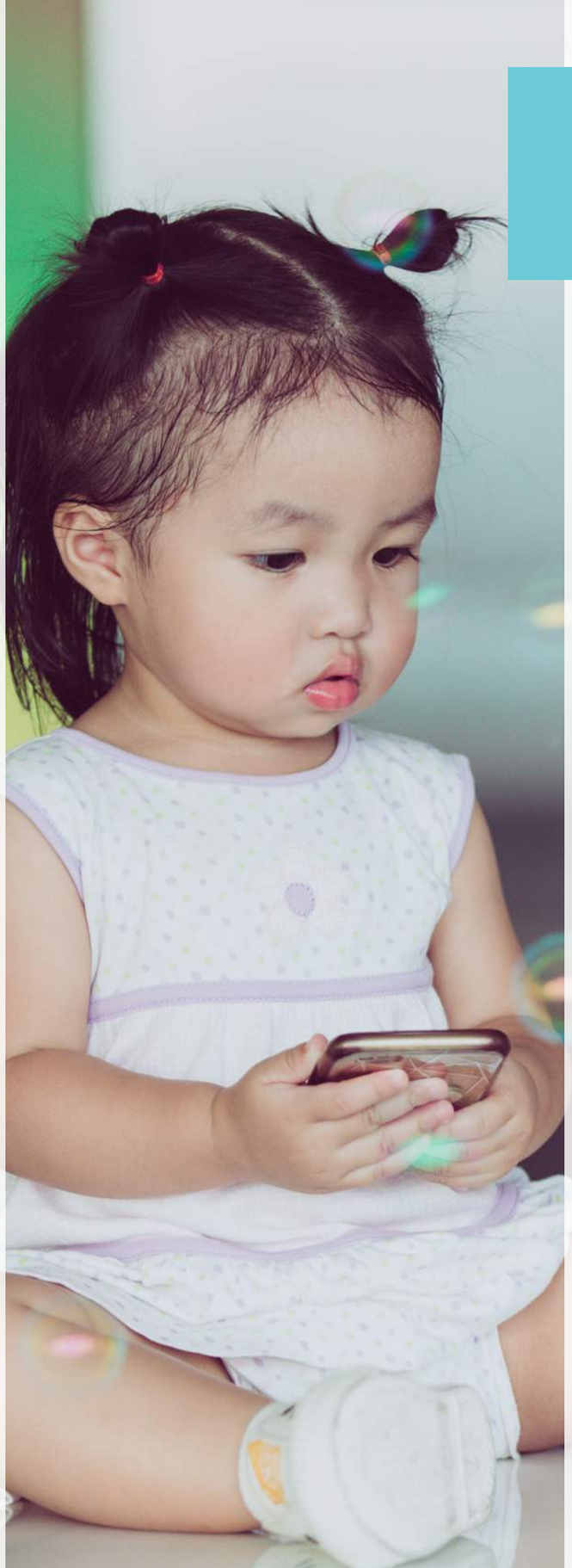
Children 4 years or younger owning smart devices



Hours of device use per day



Children are at greatest risk of the negative health consequences of excessive device use due to the fact that their bodies are still developing. Despite this, children and adolescents are continuing to use smart devices at younger ages and for longer periods of time. One study reported that up to 97% of children aged 4 years or younger regularly use smart devices and almost three quarters of children in the same age group have their own devices.[10] Alarmingly, it has been reported that up to half of children aged below 1 year use devices daily, often for up to one hour per day.[10] Preschoolers and primary school children have been found to spend even more time on devices, with an average of three and five hours of use per day, respectively.[11, 12] The amount of device screen time further increases in teenagers, with one study reporting that teenagers in the United States spend more than seven hours per day on smart devices.[13]



WHY IS TOO MUCH SCREEN TIME SO BAD FOR YOUR HEALTH?

A mounting body of research has linked excessive smart device use to a range of serious health problems. The tendency for users to remain sedentary while spending unnaturally long periods of time on their devices may increase the risk of chronic diseases such as diabetes, cancer, obesity and heart disease. Maintaining incorrect posture while using devices has also been linked to musculoskeletal disorders, while internet addiction and social isolation have been linked to an array of mental illnesses. Additionally, evidence has linked excessive screen-based activity to a number of eye health problems.

CHRONIC DISEASES

Research has linked excessive use of smart devices and personal computers with potentially fatal chronic diseases, with each additional daily hour of device use reported to increase the risk of heart disease and cancer by 3 - 5%.[14] The risk of chronic diseases associated with too much screen time doubles for people with low levels of physical activity, which is a common behaviour seen in people with compulsive device use.[14] More research is required to better understand the relationship between device use and chronic diseases.

A study of children aged 9 – 10 years reported that 3 hours or more of daily screen time increases the risk of type 2 diabetes, partly due to elevated levels of body fat and the development of resistance to insulin, a hormone responsible for controlling blood sugar levels, which may result from sedentary behaviour and poor diet in those who use devices excessively.[15]

MUSCULOSKELETAL DISORDERS

Too much device use has been found to be related to musculoskeletal problems, such as neck, shoulder and hand pain.[16, 17] Two commonly reported smart device-related muscle and bone problems are 'text neck' and 'smartphone thumb'. 'Text neck' occurs when device users slouch and bend their heads down and forward during long periods of smart device use. Text neck leads to rounded shoulders, tenderness, stiffness, soreness and weakness in the neck, back and shoulder muscles, as well as reduced neck mobility.[16] 'Smartphone thumb' is a condition caused by the repetitive motion of typing on a flat smartphone screen, which affects the wrist joint and causes pain around the thumb.[17]

MENTAL HEALTH

Research has linked excessive device use with numerous mental health conditions.[18-20] Internet Addiction Disorder (IAD) is now officially recognised by the World Health Organization as a mental health problem and is considered an emerging public health crisis, particularly for young people.[21] Indeed, similar brain changes have been observed in IAD and drug addiction.[22] As many as one-third of Chinese university students have IAD, and the problem has become so serious that more than 250 IAD boot camps have been set up to tackle the problem.[23]

IAD and excessive device use in turn may increase the risk of depression, anxiety and social isolation.[21, 24] A 2015 study on Canadian students aged 12 – 18 years reported that those who spent more than 2 hours daily on smart devices had higher levels of depression and suicidal thoughts.[18] Research in Europe, North America, Australia and Asia has suggested that people who have less than one hour of screen time per day may have a lower risk of depression.[19] A decrease in face-to-face interactions resulting from spending too much time on devices may ultimately cause social anxiety and isolation, which negatively affects the quality of relationships.[25] However, these associations must also be taken with caution given that more research is required to better understand the link between excessive device use and mental health.[26]

SCREEN TIME AND EYE HEALTH

5 BILLION PEOPLE

Half of the world's population predicted to have myopia by 2050.

SCREEN TIME

Amount of daily device use is linked to increased risk of myopia.

Some of the most common health problems associated with excessive screen time involve the eyes. Among children and teenagers, the most important eye-related issue associated with too much screen time is myopia or short-sightedness. Children require adequate time looking at distant objects to ensure that their eyes develop correctly so that they can focus incoming light. Research suggests that too much screen time may disrupt this process, resulting in short-sightedness that continues to deteriorate into adulthood.[27] In 2010, an estimated 2 billion people worldwide were found to have myopia, and this number is expected to increase to 5 billion (half of the world's population) by 2050.[28] Although genetics play an important role in myopia, environmental factors including too much near-work activity such as reading, writing and looking at device screens has been associated with a higher prevalence of myopia.[29-37] In places where screen addiction is most problematic, including Singapore, Taiwan, Hong Kong and South Korea, myopia affects between 80 and 97% of young adults.[38, 39] Research in many countries including Japan, China and India has linked this epidemic to screen time, with one study reporting that 4 or more hours of screen time per day increased the risk of myopia 8-fold.[29-37] However, there is still insufficient population-based research on the relationship between myopia and screen time and more studies are required.[29]

DIGITAL EYE STRAIN

People who spend extended periods of time staring at device screens are also at risk of developing a condition called digital eye strain (DES), also known as computer vision syndrome (CVS). DES has been a recognised health problem for more than 30 years.[40] The American Optometric Association defines DES as a group of eye and vision-related problems that result from prolonged computer, tablet, e-reader and cell phone use.[41] The following information in this report discusses this condition in detail.

SIGNS AND SYMPTOMS OF DIGITAL EYE STRAIN

The common signs and symptoms of DES include headache, eye dryness, irritation, redness and blurred vision.[42] These symptoms can be categorised into those that are associated with dry eye and those that are associated with the ability of the eye to change its focus through a process known as accommodation.[43]

DRY EYE, IRRITATION AND REDNESS

Dry eye is a common symptom of DES that can result in eye irritation, burning, dryness, redness and sensitivity to bright light. There are several factors that can contribute to smart device-related dry eye symptoms:

RISK FACTORS OF SMART-DEVICE RELATED DRY EYE

The duration of device screen time: Three hours or longer of screen time per day has been linked to an increase in the likelihood of developing dry eye by more than 13 times in primary school-going children from South Korea.[44, 45]

Reduced blink rate and incomplete blinks: Viewing smart device screens has been linked to dry eye through reduced blinking rates and incomplete blinking. These altered blinking patterns decrease tear production and increase tear evaporation, which may lead to dry eye.[46-48] One study suggested that the reduced blinking rates might be caused by involuntary squinting of the eyes when we use devices.[49]

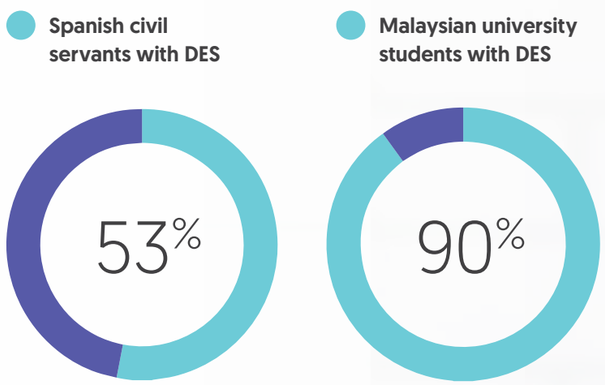
Device screen placement: The positioning of device screens higher than eye level may result in a larger opening of the eyelids and thus greater eye surface exposure.[50] This increases the amount of tear evaporation, and therefore may lead to a higher susceptibility to developing dry eye.[50, 51]

LOSS OF FOCUS

Accommodation is the ability of the eyes to shift their focus from near objects to far objects or from far objects to near objects. Exposure to smart device screens has been reported by multiple studies to negatively affect accommodation due to eye fatigue from staring at screens for long durations.[52-55] This loss of accommodation often results in blurred near and distance vision, which may cause headaches if left untreated.[42]

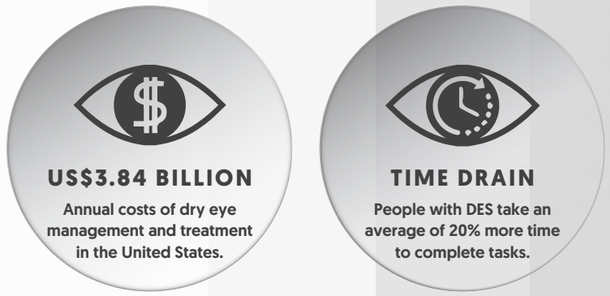
IS DIGITAL EYE STRAIN A COMMON PROBLEM?

Due to difficulties in measuring DES, there have not been many studies on the condition, and it is not well-understood how common it is, or which groups are at greatest risk. DES prevalence varies greatly between existing studies. For example, 53% of civil servants in Spain were found to have DES, while as many as 90% of Malaysian university students have been shown to have the condition.[42, 56] Very little research is available on the prevalence of DES in children, highlighting that more studies are required to understand the extent of the problem. One study estimated that as many as 20% of children have DES.[57]



DIGITAL EYE STRAIN AND SOCIETY

The economic costs related to the management and treatment of dry eye, a common symptom of DES, are high, reaching US$3.84 billion annually in the United States alone.[58] These economic costs are partly contributed to by productivity loss associated with DES, as people with DES make more errors and require longer and more frequent work breaks.[51] People with DES also require an average of 20% more time to complete many tasks, which also contributes to the overall productivity loss caused by the condition.[59] Prevention of DES through adopting healthy device use behaviours is therefore likely to have beneficial economic consequences in the long run.



SHINING LIGHT ON THE POSSIBLE CAUSE OF DIGITAL EYE STRAIN

Scientists have suggested that exposure to blue light from smart device screens may cause DES-related symptoms, such as dry eye and eye fatigue.[60-62] When blue light enters the eye, it scatters and increases the effort needed by the eyes to maintain focus. This increased effort may contribute to eye fatigue and eventually DES.[63] Exposure to excessive blue light before sleeping has also been shown to disrupt sleep patterns by disturbing the body's biological clock.[64] Just two hours of blue light exposure in the evening has been shown to suppress melatonin production, a hormone that helps induce sleep.[65] Blue light-related sleep disorders are associated with a reduced blinking rate, which leads to a decrease in tear production and an increase in tear evaporation which eventually may result in dry eye.[62, 64] However, further research is required to understand the relationship between blue light and DES, and whether there are other causes.

RISK FACTORS OF DIGITAL EYE STRAIN

SCREEN TIME

Longer screen time is a major risk factor for DES. Two studies from China and Japan reported that people who used mobile phones and computers for more than 8 hours a day were 2 times more likely to experience DES-related symptoms than those who used screens for fewer than 8 hours a day.[66, 67]

CONTACT LENS WEAR

Wearing contact lenses increases the risk of developing DES by worsening dry eye-related symptoms.[68-71] A study of American adults found that contact lens wearers were 5 times more likely to report DES symptoms, in particular dry eye, compared to those who wore spectacles.[68] These symptoms are worsened when contact lens wearers have more than 3 hours of device screen time per day.[72] However, contact lens wearers are more prone to dry eye-related DES symptoms regardless of their device screen time.

GENDER

DES appears to be more common in women than in men.[9, 43, 73, 74] A study conducted in the United States reported that 69% of women reported DES symptoms vs. 60% of men.[9] The higher prevalence of DES among females may be due to hormonal factors that reduce tear production.[75]

OCCUPATION

Working adults who are exposed to more screen time, such as office workers,[43] call centre operators,[76] bank employees,[77] and government officials,[78] tend to experience higher rates of DES. It is estimated that 90% of the 70 million US workers who use computers for 3 or more hours a day have symptoms of DES.[79] This is especially alarming given that on average, workers are exposed to 7 – 8 hours of device screen time per day.[41, 80, 81]

SCREEN TIME

More than 8 hours of screen time per day doubles DES risk.

CONTACTS

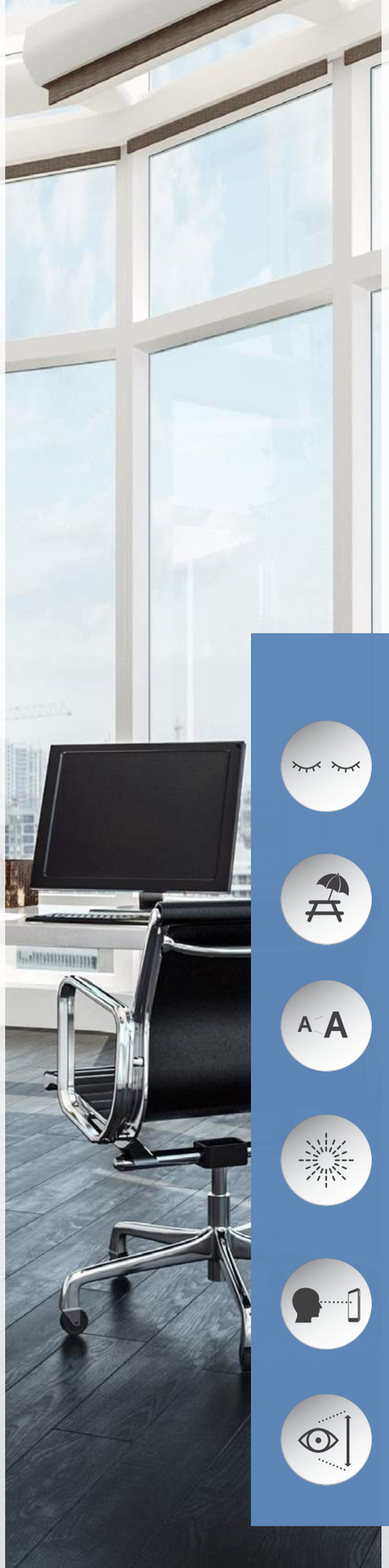
Wearing contact lenses increases DES risk by 5 times.

GENDER

69% of women and 60% of men in the US reported DES symptoms.

OCCUPATION

An estimated 90% of 70 million computer users in the US have DES.



HOW TO MANAGE DIGITAL EYE STRAIN

DIAGNOSING DIGITAL EYE STRAIN

DES is most commonly diagnosed based on responses to a questionnaire about eye symptoms.[82, 83] However, eye health professionals such as optometrists may need to perform a clinical examination to determine whether the cause of discomfort or pain is DES or another condition.

PREVENTION IS BETTER THAN CURE

Conservative management strategies of DES focus on prevention rather than cure by adopting healthy device use behaviours such as:

PREVENTIVE STRATEGIES AGAINST DIGITAL EYE STRAIN

Taking regular breaks in between periods of screen exposure: the American Optometric Association recommends taking a 15 minute break after 2 hours of device use.[41] Observing the 20-20-20 strategy (looking at objects 20 feet away for 20 seconds after 20 minutes of screen time) has also been shown to be an effective strategy for preventing DES.[56, 84]

Limiting smart device screen time and engaging in more outdoor activity: increased usage of smart devices and shorter duration of outdoor activity has been related to higher rates of DES symptoms.[45] It is recommended that children spend 2 to 3 hours outdoors per day to maintain good eye health.[27] This may also reduce their risk of developing myopia.[27, 85, 86]

Increasing text size to reduce squinting of the eyes while using devices: small text size has been shown to cause involuntary squinting of the eyes, which is associated with reduced blinking rates.[49] This often leads to reduced tear production and increases the demand on the eyes' focusing capabilities.[87] Hence, increasing text size when using devices is a potential management strategy to reduce DES symptoms.

Reducing overhead lighting and using anti-glare screens to reduce screen glare: glare from device screens and overhead lighting placed directly in front of the eyes has been linked to eye discomfort symptoms.[51] Simple changes to the location of light sources and using anti-glare screen protectors may be beneficial in reducing the amount of glare coming from screens or other light sources. Therefore, it is recommended to avoid placing light sources in a location that causes excessive reflection and glare on the screens.[51]

Adequate face-to-screen distance when using devices: people tend to hold devices closer to their faces when they use their devices for long periods of time.[88] A closer face-to-screen distance puts more strain on the eye's focusing abilities and leads to greater exposure to blue light and glare to the eyes, thereby potentially causing eye fatigue and worsening DES symptoms. It is recommended that smart devices are held at least 30cm from the face, while there should be at least 60cm of distance between the face and computer screens.[87, 89]

Location of screen: placement of device screens above eye level is associated with greater eye surface exposure to screens, and thus may lead to an increased amount of tear evaporation and a higher susceptibility to developing dry eye.[50, 51] A screen location of 15 – 20 degrees below eye level is recommended to reduce these problems.[41]

HOW TO MANAGE DIGITAL EYE STRAIN

TREATMENT

Once DES has been diagnosed, an eye health professional may choose different methods to treat the condition depending on factors such as symptom type or severity and potential environmental triggers.

CORRECTION OF REFRACTIVE ERRORS

People who have trouble seeing near or far objects due to their eyes incorrectly focusing incoming light to create a clear image are said to have a refractive error. Common refractive conditions include myopia (short-sightedness), hyperopia (far-sightedness) and astigmatism (caused by an irregularly shaped cornea or lens), and these conditions are typically corrected with spectacles or contact lenses. Research has shown that people with even very mild refractive errors are at a higher risk of developing DES if they do not have their refractive error corrected.[90, 91] Commonly-prescribed corrective spectacles may reduce DES symptoms by reducing eye strain, however some people may benefit from computer glasses which are designed specifically to allow you to focus on computer screens which are typically positioned further away than other reading material.[92-94] An optometrist may make a decision about which type of lens is most suitable for alleviating a person's DES symptoms based on an eye examination. Different lens types include:

- **Single vision lenses:** lenses that have a single power across the entire lens and are only able to correct either near vision or distance vision.
- **Bifocals:** lenses designed for near and distance viewing.
- **Trifocals:** lenses that combine a segment for distance vision, another for near vision, and a third one for vision at the screen distance.
- **Progressive lenses:** multifocal lenses designed for everyday use (near work, middle distance and far viewing).
- **Computer progressive lenses:** lenses that do not have lines between segments of different focal power and allow smooth transition while focusing on objects at different distances.

LENS TREATMENT AND FILTERS

For some people, simply correcting their refractive error with conventional lenses is not enough to resolve their DES symptoms. Lenses may be treated with filters that block out certain kinds of light such as harsh blue light to alleviate eye fatigue-related symptoms of DES.[95, 96] Coloured lenses have also been shown to alleviate DES, although evidence remains inconclusive.[63, 97] Some lens treatments and filters available to potentially combat DES include:

- **Anti-reflective coating:** reduce reflection and glare from light sources.
- **High energy visible (HEV) light filters/coatings:** designed to block out high energy visible light and ultraviolet (UV) light reflection.
- **Amber/yellow filters:** designed to filter out harmful blue and violet light emitted by device screens.

LUBRICATING EYE DROPS

Lubricating eye drops provide one of the simplest and most readily available means of alleviating DES symptoms through improving the dry eye-related symptoms of DES (fatigue, irritation and redness).[56, 98] The drops work by increasing tear volume and conserving tears, which moisturises the cornea (the transparent outer layer of the eye) and creates a smooth eye surface.[99] There are also eye drops that help restore the oily layer of tears, reducing tear evaporation and alleviating dry eye-related DES symptoms.[100]

OTHER TREATMENT OPTIONS

There is some evidence for the effectiveness of alternative treatment options for DES, including oral omega-3 fatty acid supplements and blueberry extracts.[101, 102] Both of these alternative treatments may help to relieve DES by reducing dry eye symptoms. A study investigating the effects of omega-3 fatty acid supplements on DES reported that 70% of those given daily omega-3 fatty acid capsules became symptom-free after 3 months of treatment[101] and just 4 weeks of daily treatment with blueberry extract has been shown to reduce tablet computer-related DES symptoms by almost 90%.[102]

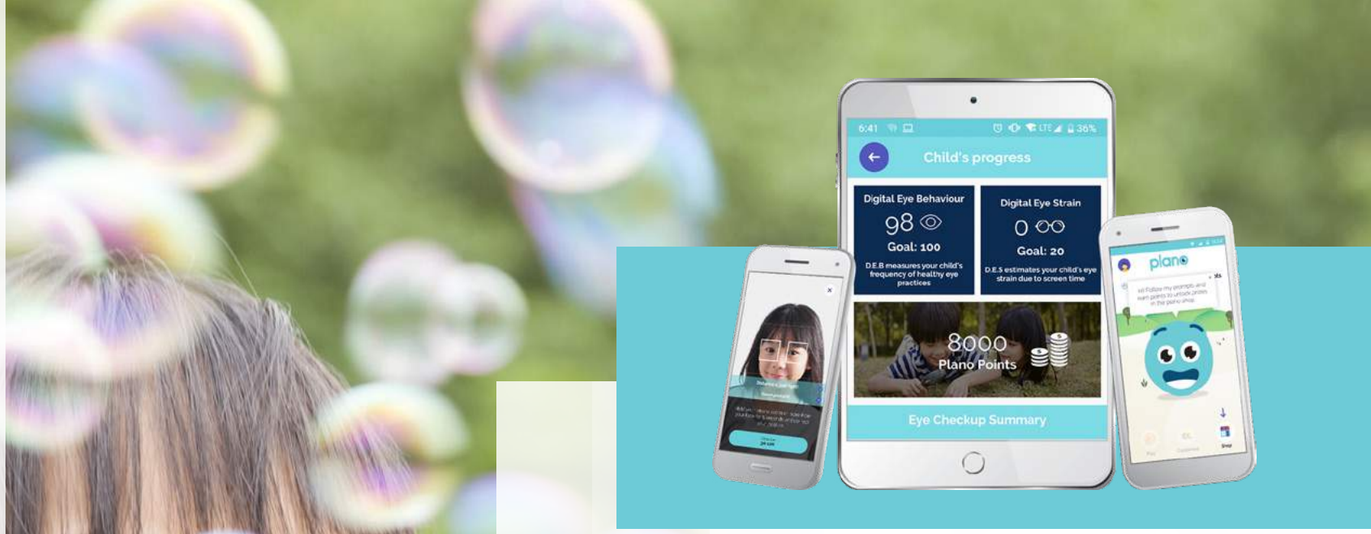
INTRODUCING PLANO, THE APP THAT IS TURNING THE PROBLEM INTO THE SOLUTION

Treatment of DES is not always effective, and once symptoms have begun to develop, your eyes have already undergone a lot of strain for extended periods of time. The most effective way to minimise the risk of DES is to develop healthier relationships with the devices that cause the condition. However, without proper instructions and reminders, it is difficult to know how to manage our device use. When we are engrossed in screen-based activities, we often lose track of time and are not mindful of the need to take breaks or to hold devices at the correct distance. This is a problem both for children who use their devices for entertainment or educational purposes and for professional adults who work with computer screens for many hours per day. Therefore, a technological device-based solution is required to help you to monitor your own device use as well as that of your children.

plano is a health technology company that manages device use and eye health in people worldwide, with the plano app as its main product. The functions and features of the plano app were developed to address the problem of unhealthy device use based on science and market research. The plano app's functions focus on empowering device users to develop their own good device use behaviours, while allowing device use behaviours to be monitored to ensure compliance with healthy device use guidelines. This empowerment-based approach creates long-term behavioural changes that result in a healthier tech-life balance.

In order to assist working adults to maintain healthy device use habits, plano works with industries to conduct corporate expert talks through its plano@work service. Through this service, plano can work together with companies to create a vision-friendly workplace by ensuring that employees develop healthier relationships with technology. Some of the main offerings of the service include:

- Expert talks on excessive device use and associated eye health problems.
- Staff training on methods to improve work productivity and job satisfaction through good eye care habits and responsible device use.
- Evidence-based recommendations to achieve a vision-friendly workplace.



PLANO APP FUNCTIONS INCLUDE:

- Allowing parents to monitor and control their child's device use remotely.
- Remote locking of the devices.
- Blocking malicious applications and browsers.
- Sending prompts to remind users to take regular breaks, look far into the distance and encourage them to spend time outdoors.
- Detecting and monitoring face-to-screen distance and posture, and notifying users to correct their distance and posture when required.
- Providing smart referrals to optometrists for users to ensure timely and regular comprehensive eye tests.
- Sending reports on device use activity and behaviour.
- Rewarding children who follow the healthy device use guidelines with points so they can send a wish list of family-friendly activities and merchandise to their parents from plano's partner vendors through the plano shop.

SUMMARY

DES, also known as computer vision syndrome, is a disorder of the eyes that is associated with excessive time engaged in screen-based activities on computers and smart devices. The rapid increase in smart device uptake, driven by increased affordability and convenience of devices, has increased the amount of screen time experienced by people around the world. As the amount of screen time increases, the risk of developing a number of health problems rises accordingly. DES is an avoidable eye condition resulting from excessive use of devices that may cause pain, discomfort, loss of productivity and reduced quality of life. There is a need for adults and children to adopt healthy device use behaviours to prevent DES or manage its severity once symptoms occur. The plano app runs seamlessly in the background of devices and helps to ensure that you and your family continue to enjoy happy and healthy lives while using your devices.

CONTACTS

Associate Professor Mo Dirani
Managing Director, Plano Pte Ltd
mo.dirani@plano.co

DISCLOSURE

Author Associate Professor Mohamed Dirani is the founding Managing Director of Plano Pte Ltd and a shareholder of the company. Author Mr. Arief Tjitra Salim is a full time employee of Plano Pte Ltd and authors Dr. Stuart Keel and Dr. Joshua Foreman hold Research Consultant appointments with the company. Reviewer Professor Jonathan Crowston is a non-executive, Independent Board Director of Plano Pte Ltd. No other disclosures.

REFERENCES

1. Statista. Share of households with a computer at home worldwide from 2005 to 2018. 2019.
2. We Are Social. Digital in 2018: World's Internet Users Pass the 4 Billion Mark. 2018.
3. Statista. Tablet user penetration worldwide as share of population from 2014 to 2021. 2019.
4. Statista. Smartphone user penetration as percentage of total global population from 2014 to 2021. 2019.
5. Internet World Stats. Internet Growth Statistics. 2018.
6. Pew Research Center. Mobile Fact Sheet. 2018.
7. Nielsen. The Nielsen Total Audience Report: Q1 2018. 2018.
8. Ofcom. Adults' Media Use and Attitudes Report. 2018.
9. The Vision Council. Eyes Overexposed: The Digital Device Dilemma. 2016.
10. Kabali HK, Irigoyen MM, Nunez-Davis R, et al. Exposure and Use of Mobile Media Devices by Young Children. Pediatrics 2015;136(6):1044-50.
11. Vanderloo LM. Screen-viewing among preschoolers in childcare: a systematic review. BMC pediatrics 2014;14:205-.
12. DQ Institute. 2018 National DQ Impact Report. 2018.
13. Twenge JM, Campbell WK. Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population-based study. Preventive Medicine Reports 2018;12:271-83.
14. Celis-Morales CA, Lyall DM, Steell L, et al. Associations of discretionary screen time with mortality, cardiovascular disease and cancer are attenuated by strength, fitness and physical activity: findings from the UK Biobank study. BMC Med 2018;16(1):77.
15. Nightingale CM, Rudnicka AR, Donin AS, et al. Screen time is associated with adiposity and insulin resistance in children. Arch Dis Child 2017;102(7):612-6.
16. Vate-U-Lan P. Text Neck Epidemic: a Growing Problem for Smart Phone Users in Thailand. The Twelfth International Conference on eLearning for Knowledge-Based Society 2015.
17. Xiong J, Muraki S. An ergonomics study of thumb movements on smartphone touch screen. Ergonomics 2014;57(6):943-55.
18. Sampasa-Kanyinga H, Lewis RF. Frequent Use of Social Networking Sites Is Associated with Poor Psychological Functioning Among Children and Adolescents. Cyberpsychol Behav Soc Netw 2015;18(7):380-5.
19. Liu M, Wu L, Yao S. Dose-response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. Br J Sports Med 2016;50(20):1252-8.
20. Park J, Kim J, Kim J, et al. The effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles and depression2015; 12-7.
21. World Health Organization. Public health implications of excessive use of the internet, computers, smartphones and similar electronic devices: meeting report, Main Meeting Hall, Foundation for Promotion of Cancer Research, National Cancer Research Centre, Tokyo, Japan, 27-29 August 2014. 2015.
22. Yuan K, Qin W, Wang G, et al. Microstructure abnormalities in adolescents with internet addiction disorder. PLoS One 2011;6(6):e20708.
23. Smithsonian.com. China Now Has Up to 250 Boot Camps to Cure Teens of Internet Addiction. 2014.
24. Kwon JH, Chung CS, Lee J. The effects of escape from self and interpersonal relationship on the pathological use of Internet games. Community Ment Health J 2011;47(1):113-21.
25. Livingstone S, Haddon L, Goerzig A, Ólafsson K. Risks and Safety on the Internet: The Perspective of European Children. Full FINDINGS2011.
26. The Lancet. Social media, screen time, and young people's mental health. The Lancet 2019;393(10172):611.
27. Foreman J, Dirani M. Keeping an eye on smart device use. Singapore2018.
28. Holden BA, Fricke TR, Wilson DA, et al. Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050. Ophthalmology 2016;123(5):1036-42.
29. Dirani M, Crowston JG, Wong TY. From reading books to increased smart device screen time. British Journal of Ophthalmology 2019;103(1):1.
30. Saxena R, Vashist P, Tandon R, et al. Prevalence of myopia and its risk factors in urban school children in Delhi: the North India Myopia Study (NIM Study). PloS one 2015;10(2):e0117349-e.
31. Zhou J, Ma Y, Ma J, et al. [Prevalence of myopia and influencing factors among primary and middle school students in 6 provinces of China]. Zhonghua Liu Xing Bing Xue Za Zhi 2016;37(1):29-34.
32. Terasaki H, Yamashita T, Yoshihara N, et al. Association of lifestyle and body structure to ocular axial length in Japanese elementary school children. BMC Ophthalmol 2017;17(1):123.
33. Czepita M, Czepita D, Lubiński W. The Influence of Environmental Factors on the Prevalence of Myopia in Poland. Journal of ophthalmology 2017;2017:5983406-.
34. Czepita D, Mojsa A, Ustianowska M, et al. Reading, writing, working on a computer or watching television, and myopia. Klin Oczna 2010;112(10-12):293-5.
35. Khader YS, Batayha WQ, Abdul-Aziz SM, Al-Shiekh-Khalil MI. Prevalence and risk indicators of myopia among schoolchildren in Amman, Jordan. East Mediterr Health J 2006;12(3-4):434-9.
36. Konstantopoulos A, Yadegarfar G, Elgohary M. Near work, education, family history, and myopia in Greek conscripts. Eye (Lond) 2008;22(4):542-6.
37. You QS, Wu LJ, Duan JL, et al. Factors associated with myopia in school children in China: the Beijing childhood eye study. PloS one 2012;7(12):e52668-e.
38. Morgan IG, French AN, Ashby RS, et al. The epidemics of myopia: Aetiology and prevention. Prog Retin Eye Res 2018;62:134-49.
39. Pan CW, Dirani M, Cheng CY, et al. The age-specific prevalence of myopia in Asia: a meta-analysis. Optom Vis Sci 2015;92(3):258-66.
40. Dain SJ, McCarthy AK, Chan-Ling T. Symptoms in VDU operators. Am J Optom Physiol Opt 1988;65(3):162-7.
41. American Optometric Association. Computer Vision Syndrome. 2017.
42. Sheppard AL, Wolffsohn JS. Digital eye strain: prevalence, measurement and amelioration. BMJ Open Ophthalmology 2018;3(1):e000146.
43. Portello JK, Rosenfield M, Bababekova Y, et al. Computer-related visual symptoms in office workers. Ophthalmic Physiol Opt 2012;32(5):375-82.
44. Moon JH, Lee MY, Moon NJ. Association between video display terminal use and dry eye disease in school children. J Pediatr Ophthalmol Strabismus 2014;51(2):87-92.
45. Moon JH, Kim KW, Moon NJ. Smartphone use is a risk factor for pediatric dry eye disease according to region and age: a case control study. BMC ophthalmology 2016;16(1):188-.
46. Patel S, Henderson R, Bradley L, et al. Effect of visual display unit use on blink rate and tear stability. Optom Vis Sci 1991;68(11):888-92.
47. Freudenthaler N, Neuf H, Kadner G, Schlote T. Characteristics of spontaneous eyeblink activity during video display terminal use in healthy volunteers. Graefes Arch Clin Exp Ophthalmol 2003;241(11):914-20.
48. Argiles M, Cardona G, Perez-Cabre E, Rodriguez M. Blink Rate and Incomplete Blinks in Six Different Controlled Hard-Copy and Electronic Reading Conditions. Invest Ophthalmol Vis Sci 2015;56(11):6679-85.
49. Sheedy JE, Gowrisankaran S, Hayes JR. Blink rate decreases with eyelid squint. Optom Vis Sci 2005;82(10):905-11.
50. Agarwal S, Goel D, Sharma A. Evaluation of the Factors which Contribute to the Ocular Complaints in Computer Users. Journal of clinical and diagnostic research : JCDR 2013;7(2):331-5.
51. Rosenfield M. Computer vision syndrome (a.k.a. digital eye strain). Vol. 172016; 1-10.
52. Wick B, Morse S. Accommodative accuracy to video display monitors. Vol. 792002; 218.
53. Penisten DK, Goss DA, Philpott G, et al. Comparisons of dynamic retinoscopy measurements with a print card, a video display terminal, and a PRIO System Tester as test targets. Optometry 2004;75(4):231-40.
54. Collier JD, Rosenfield M. Accommodation and convergence during sustained computer work. Optometry 2011;82(7):434-40.
55. Rosenfield M, Gurevich R, Wickware E, Lay M. Computer Vision Syndrome: Accommodative and Vergence Facility. Investigative Ophthalmology & Visual Science 2009;50(13):5332-.
56. Reddy SC, Low CK, Lim YP, et al. Computer vision syndrome: a study of knowledge and practices in university students. Nepal J Ophthalmol 2013;5(2):161-8.
57. Vilela MA, Pellanda LC, Fassa AG, Castagno VD. Prevalence of asthenopia in children: a systematic review with meta-analysis. J Pediatr (Rio J) 2015;91(4):320-5.
58. Yu J, Asche CV, Fairchild CJ. The economic burden of dry eye disease in the United States: a decision tree analysis. Cornea 2011;30(4):379-87.
59. Daum KM, Clore KA, Simms SS, et al. Productivity associated with visual status of computer users. Optometry 2004;75(1):33-47.
60. Ham Jr WT, Mueller HA, Sliney DH. Retinal sensitivity to damage from short wavelength light. Nature 1976;260:153.
61. Jaadane I, Boulenguez P, Chahory S, et al. Retinal damage induced by commercial light emitting diodes (LEDs). Free Radic Biol Med 2015;84:373-84.
62. Zhao Z-C, Zhou Y, Tan G, Li J. Research progress about the effect and prevention of blue light on eyes. International journal of ophthalmology 2018;11(12):1999-2003.
63. Coles-Brennan C, Sulley A, Young G. Management of digital eye strain. Clin Exp Optom 2019;102(1):18-29.
64. Gabel V, Reichert CF, Maire M, et al. Differential impact in young and older individuals of blue-enriched white light on circadian physiology and alertness during sustained wakefulness. Scientific Reports 2017;7(1):7620.
65. Tahkamo L, Partonen T, Pesonen AK. Systematic review of light exposure impact on human circadian rhythm. Chronobiol Int 2019;36(2):151-70.
66. Li S, He J, Chen Q, et al. Ocular surface health in Shanghai University students: a cross-sectional study. BMC Ophthalmol 2018;18(1):245.
67. Uchino M, Yokoi N, Uchino Y, et al. Prevalence of dry eye disease and its risk factors in visual display terminal users: the Osaka study. Am J Ophthalmol 2013;156(4):759-66.
68. Nichols JJ, Ziegler C, Mitchell GL, Nichols KK. Self-reported dry eye disease across refractive modalities. Invest Ophthalmol Vis Sci 2005;46(6):1911-4.
69. Chalmers RL, Begley CG. Dryness symptoms among an unselected clinical population with and without contact lens wear. Cont Lens Anterior Eye 2006;29(1):25-30.
70. Kojima T, Ibrahim OM, Wakamatsu T, et al. The impact of contact lens wear and visual display terminal work on ocular surface and tear functions in office workers. Am J Ophthalmol 2011;152(6):933-40.e2.
71. Tauste A, Ronda E, Molina MJ, Segui M. Effect of contact lens use on Computer Vision Syndrome. Ophthalmic Physiol Opt 2016;36(2):112-9.
72. Gonzalez-Meijome JM, Parafita MA, Yebra-Pimentel E, Almeida JB. Symptoms in a population of contact lens and noncontact lens wearers under different environmental conditions. Optom Vis Sci 2007;84(4):296-302.
73. Courtin R, Pereira B, Naughton G, et al. Prevalence of dry eye disease in visual display terminal workers: a systematic review and meta-analysis. BMJ Open 2016;6(1):e009675.
74. Porcar E, Pons AM, Lorente A. Visual and ocular effects from the use of flat-panel displays. International journal of ophthalmology 2016;9(6):881-5.
75. Guillon M, Maissa C. Tear film evaporation--effect of age and gender. Cont Lens Anterior Eye 2010;33(4):171-5.
76. Sa EC, Ferreira Junior M, Rocha LE. Risk factors for computer visual syndrome (CVS) among operators of two call centers in Sao Paulo, Brazil. Work 2012;41 Suppl 1:3568-74.
77. Assefa NL, Weldemichael DZ, Alemu HW, Anbesse DH. Prevalence and associated factors of computer vision syndrome among bank workers in Gondar City, northwest Ethiopia, 2015. Clinical optometry 2017;9:67-76.
78. Dessie A, Adane F, Nega A, et al. Computer Vision Syndrome and Associated Factors among Computer Users in Debre Tabor Town, Northwest Ethiopia. Journal of environmental and public health 2018;2018:4107590-.
79. Tr A, Yj M. Impact of Computer Technology on Health: Computer Vision Syndrome (CVS). Vol. 52014; 20-30.
80. Antunes ED, de Araujo CR, Abage Z. Musculoskeletal symptoms in workers of a Telecom Company. Work 2012;41 Suppl 1:5725-7.
81. Radulovic B, Hursidic-Radulovic A. Frequency of musculoskeletal and eye symptoms among computer users at work. Arh Hig Rada Toksikol 2012;63(2):215-8.
82. Benedetto S, Drai-Zerbib V, Pedrotti M, et al. E-readers and visual fatigue. PloS one 2013;8(12):e83676-e.
83. Segui Mdel M, Cabrero-Garcia J, Crespo A, et al. A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace. J Clin Epidemiol 2015;68(6):662-73.
84. Tribley J, McClain S, Karbasi A, Kaldenberg J. Tips for computer vision syndrome relief and prevention. Work 2011;39(1):85-7.
85. Wu PC, Tsai CL, Wu HL, et al. Outdoor activity during class recess reduces myopia onset and progression in school children. Ophthalmology 2013;120(5):1080-5.
86. Dirani M, Tong L, Gazzard G, et al. Outdoor activity and myopia in Singapore teenage children. Br J Ophthalmol 2009;93(8):997-1000.
87. Rosenfield M. Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic and Physiological Optics 2011;31(5):502-15.
88. Bao J, Drobe B, Wang Y, et al. Influence of Near Tasks on Posture in Myopic Chinese Schoolchildren. Optometry and vision science : official publication of the American Academy of Optometry 2015;92(8):908-15.
89. Bababekova Y, Rosenfield M, Hue JE, Huang RR. Font size and viewing distance of handheld smart phones. Optom Vis Sci 2011;88(7):795-7.
90. Wiggins NP, Daum KM. Visual discomfort and astigmatic refractive errors in VDT use. J Am Optom Assoc 1991;62(9):680-4.
91. Wiggins NP, Daum KM, Snyder CA. Effects of residual astigmatism in contact lens wear on visual discomfort in VDT use. J Am Optom Assoc 1992;63(3):177-81.
92. Butzon SP, Sheedy JE, Nilsen E. The efficacy of computer glasses in reduction of computer worker symptoms. Optometry 2002;73(4):221-30.
93. Wallin JA, Zhu Z, Jacobsen JL, Jacobsen SD. A preliminary study of the effects of computer glasses on reported VDT user symptoms: a field study. Journal of Safety Research 1994;25(2):67-76.
94. Cagnie B, De Meulemeester K, Saeys L, et al. The impact of different lenses on visual and musculoskeletal complaints in VDU workers with work-related neck complaints: a randomized controlled trial. Environmental health and preventive medicine 2017;22(1):8-.
95. Ide T, Toda I, Miki E, Tsubota K. Effect of Blue Light-Reducing Eye Glasses on Critical Flicker Frequency. Asia Pac J Ophthalmol (Phila) 2015;4(2):80-5.
96. Lin JB, Gerratt BW, Bassi CJ, Apte RS. Short-Wavelength Light-Blocking Eyeglasses Attenuate Symptoms of Eye Fatigue. Invest Ophthalmol Vis Sci 2017;58(1):442-7.
97. Simmers AJ, Gray LS, Wilkins AJ. The influence of tinted lenses upon ocular accommodation. Vision Res 2001;41(9):1229-38.
98. Guillon M, Maissa C, Pouliquen P, Delval L. Effect of povidone 2% preservative-free eyedrops on contact lens wearers with computer visual syndrome: pilot study. Eye Contact Lens 2004;30(1):34-9.
99. Tong L, Petznick A, Lee S, Tan J. Assessment and Management of Dry Eye Patients for Non-Ophthalmic Healthcare Practitioners. Vol. 212012.
100. Benelli U. Systane lubricant eye drops in the management of ocular dryness. Clinical ophthalmology (Auckland, NZ) 2011;5:783-90.
101. Bhargava R, Kumar P, Phogat H, et al. Oral omega-3 fatty acids treatment in computer vision syndrome related dry eye. Cont Lens Anterior Eye 2015;38(3):206-10.
102. Park CY, Gu N, Lim C-Y, et al. The effect of Vaccinium uliginosum extract on tablet computer-induced asthenopia: randomized placebo-controlled study. BMC complementary and alternative medicine 2016;16:296-.

plano®, your smart device friend.

The plano® mobile app has a number of functions to ensure safe and healthy smart device use in children, with key features supported by scientific evidence. Now available on the Google Play Store and Apple App Store.

For more information, please visit www.plano.co