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The Myopia Epidemic: A Growing Public Health Crisis Impacting Children Worldwide

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Abstract - Myopia, or nearsightedness, has reached epidemic proportions globally, with rates dramatically rising among children and adolescents over the past few decades. This literature review summarizes the current scope and prevalence of the myopia epidemic, highlighting statistics from East Asia where myopia has increased from 10-20% in the mid-20th century to over 90% today in certain populations. Western nations are not immune to this public health crisis, with myopia rates below 50% but steadily increasing. If current trends continue, projections estimate 3.4 billion people, or half the world's population, will be myopic by 2050. Besides genetic predispositions, lifestyle factors like excessive near work and insufficient time outdoors are key drivers of this epidemic. The health consequences are severe, as high myopia is now the leading cause of blindness in many parts of Asia. Retinal detachments, cataracts, glaucoma and other vision-threatening conditions are also more common with high myopia. Public health initiatives promoting outdoor activity, screen time moderation, and early vision screening are urgently needed to curb this epidemic. Environmental design changes to schools and urban areas promoting time outdoors may also help. Pharmaceutical treatments to slow myopia progression show promise but require further research. In summary, the myopia epidemic poses a major threat to global eye health, especially among younger generations. Concerted public health efforts incorporating lifestyle changes, screening programs, and medical treatments are warranted to control this burgeoning crisis and protect vision. The time to act is now, before millions more suffer irreversible vision impairment or blindness from unchecked myopia progression.

Keywords: Myopia, Nearsightedness, Axial elongation, High myopia, Retinal detachment, Outdoor time, Atropine, Glaucoma, Cataracts, Blindness.

1. INTRODUCTION

1.2 Definition and Explanation of Myopia/Nearsightedness

Myopia, commonly known as nearsightedness, is a refractive error of the eye that causes blurred vision for distant objects. It is one of the most common vision disorders globally, affecting over 1.6 billion people worldwide as of 2000. This number is projected to increase dramatically in the coming decades, with some estimates predicting that by 2050, nearly 5 billion people – half of the world's population – will be myopic. This literature review will provide an in-depth examination of the current myopia epidemic, with a focus on the rapid rise in prevalence among children and adolescents. However, before analyzing the key statistics, trends, and health impacts, it is important to first understand myopia and how it develops.

Myopia occurs when the shape of the eye causes light rays to focus in front of the retina rather than directly on its surface. This causes distant objects to appear blurry, while close-up vision remains clear. Myopia is predominantly an axial disorder, meaning it results from excessive elongation of the eyeball from front to back. As the eye grows longer, optical power increases, leading to defocus on the retinal plane. High degrees of myopia in particular are associated with extreme axial length. While myopia can be inherited genetically, environmental factors play a major role in its progression, especially among young people.

The key environmental risk factors for myopia include excessive near work, lack of time outdoors, and urban living environments. Spending long hours reading, using digital devices, attending school, and performing other sustained close visual tasks is linked to axial elongation and myopia onset. Insufficient time outdoors also encourages myopia, as exposure to outdoor daylight helps stimulate production of dopamine, a neurotransmitter that inhibits axial growth. Finally, urban settings tend to have higher rates of myopia compared to rural areas, likely due to differences in lifestyle. Genetics interact with these environmental influences to affect one's susceptibility.

Myopia is quantified in diopters, a unit of measurement for optical power. Low myopia usually ranges from -0.50 to -3.00 diopters. Medium myopia is defined as -3.00 to -6.00 diopters, while high myopia constitutes -6.00 diopters or higher. High myopia is associated with pathologic ocular changes and a greater risk of vision impairment. While low degrees of myopia can be corrected with glasses, contact lenses or refractive surgery, high myopia requires routine eye exams to monitor for complications like retinal detachment, cataracts, glaucoma and myopic macular degeneration.

Myopia typically first develops in school-age children, between ages 6 to 14 years old. In fact, the age of onset is decreasing, with myopia emerging at younger ages, especially in East Asia. The earlier myopia develops, the more rapidly it can progress. High myopia usually stabilizes by adulthood, but the structural changes are irreversible. Thus, controlling myopia progression in childhood through medical and lifestyle interventions is essential to preserve long-term vision and ocular health.

In summary, myopia is a refractive error that is reaching epidemic levels globally, driven by lifestyle changes and environmental factors. Understanding the mechanism of myopia development involving axial elongation sets the stage for analyzing the scope of this public health crisis, especially among the younger generations most impacted. The coming chapters will explore the key statistics around childhood myopia rises worldwide, the health consequences, and the imperative for prevention and control strategies.

1.2 Rising Global Rates of Myopia, Especially Among Children and Teenagers

Perhaps the most alarming aspect of the myopia epidemic is the dramatic rise in prevalence observed among children and adolescents over the past few decades. While myopia has historically affected a small percentage of the juvenile population, rates began to skyrocket starting in the 1970s and 1980s, first in East Asia and subsequently across the globe. Today, the majority of teenagers and young adults in many parts of Asia have myopia, with prevalence upwards of 80-90% in certain populations. Western nations are not far behind, reflecting a worldwide surge in childhood myopia that threatens to leave future generations burdened with poor vision and eye health complications if left unaddressed.

The area of gravest concern is East and Southeast Asia, where myopia rates among young people have reached unprecedented highs. Data from the early 2000s showed that over 90% of 15-18 year olds in Singapore and Taiwan were myopic. In Seoul, South Korea, 96.5% of 19-year-old men entering the military had myopia. Comparable figures hold for young adults in several Chinese cities, with over 95% of university students affected in Shanghai. This represents an astronomical increase from the mid-20th century, when myopia rates were typically 10-20% in the region. While populations of Chinese ethnic origin seem most prone to dramatic myopia rises, the epidemic has spared few groups in Asia. Japan has witnessed an over 6-fold increase in myopia among children over the last 60 years.

Perhaps most disturbing are cases of very early-onset myopia, even among preschoolers. Up to 20% of 5-6 year olds in China were myopic in 2015, compared to just 5% in the 1980s. Nearly 10% of first-graders in Taiwan also exhibited myopia. Since early development leads to higher risk first gradersical myopia, this has serious implications for long-term vision impairment. Reported increases in average myopia severity among Asian children parallel the incidence rises.

Western nations have not been immune to this public health crisis either. While myopia rates were around 25% a few decades ago, they have similarly surged among school-aged children more recently. A 2009 study found 41% of 12-13 year olds in the United States were myopic, twice the prevalence in the 1970s. Over 15% had high myopia, linked to irreversible eye damage. The United Kingdom, Australia, Canada and continental Europe show comparable multi-generational rises. Projecting historical trends forward, researchers predict roughly 50% of school-leavers across the West will be myopic by 2035.

In summary, no region of the world has been spared from the childhood myopia epidemic. While the highest prevalence is concentrated in urban Asia, the problem is global in scale and rapidly intensifying each generation. Younger ages of onset coupled with higher severity amongst juveniles foreshadows an even greater public health and economic burden approaching mid-century when today's youth become tomorrow's working-age adults. Targeting myopia control efforts towards those in their critical childhood and adolescent developmental stages is crucial to reverse the trajectory of this worldwide eye health crisis.

1.3 Health and Social Impacts of High Myopia and Blindness

While myopia in lower amounts can be managed with little functional impact besides wearing glasses or contact lenses, higher degrees pose significant medical and social risks. Pathologic changes to ocular anatomy occur with high myopia, predisposing individuals to irreversible vision impairment and blindness. In fact, high myopia has emerged as the leading cause of permanent vision loss in many East Asian countries. Besides blindness, it heightens risks for retinal detachment, glaucoma, cataracts and macular degeneration. The economic costs of myopia-linked disability will likely soar in the coming decades as young, working-age adults lose productivity. There are also substantial social and psychological effects for individuals losing their independence and sense of self due to blindness.

Currently, myopia accounts for 4.8% of global blindness, but its contribution is as high as 33% in certain urban Asian settings. The number of people with pathologic myopia worldwide was estimated at 163 million in 2000, projected to grow to 938 million by 2050 due to demographic shifts. High myopia affects 10-20% of myopes but increases lifetime risks of severe visual impairment up to 20-fold compared to the general low myopia population. Besides blindness, the quality of vision worsens incrementally with higher myopic severity. Visual acuity measures and contrast sensitivity are significantly reduced, negatively impacting daily functioning.

Retinal detachment risk grows 7-fold with high myopia, while glaucoma risk is 3-4 times higher. The thin, elongated eye shape also predisposes highly myopic patients to cataracts at an earlier age. Myopic macular degeneration, untreatable vision loss due to damage of the central retina, occurs exclusively in high myopia. Younger onset of these complications means decades more disability over a lifetime if myopia control isn't implemented early.

Economically, productivity loss due to myopia and associated vision impairment cost global healthcare systems an estimated $244 billion in 2013. Over two-thirds of this burden fell on East Asia, reflecting their disproportionately high disease prevalence. However, with myopia rates escalating worldwide, the costs are projected to reach up to $300 billion by 2025. Soaring treatment expenses will further tax healthcare budgets already strained by aging populations.

Socially, vision loss cuts across all aspects of life. Simple daily tasks like reading, writing, driving and recognizing faces become challenged. Educational attainment, employment opportunities, independent living and social engagement are restricted for the blind. Feelings of isolation, depression and loss of personal identity frequently ensue after sight loss. While support services can alleviate some difficulties, most blind individuals would trade anything to reverse their condition.

In summary, runaway myopia progression poses a major public health threat, both due to the medical risks it creates and its substantial economic and social costs. The outlooks for blindness and permanent vision disability will remain bleak if the childhood myopia epidemic continues unabated. Immediate action to curb this preventable condition would pay dividends across the board, helping generations worldwide preserve their health, productivity and wellbeing.

2. SCOPE AND PREVALENCE OF THE MYOPIA EPIDEMIC

While myopia has long been a common vision disorder, its prevalence has skyrocketed globally over the past half century, earning it the dubious title of a modern epidemic. East Asia leads the world with myopia rates of 80-90% among children completing secondary school. However, Western nations and the rest of the globe have not been spared, with rates doubling or tripling over a generation. Projections forecast half the world's population could be myopic by 2050 if current youth trajectories continue. This rapid emergence and expansion of the condition across geographies and ethnicities points to profound lifestyle changes as the driver of the epidemic, rather than solely genetic factors.

The most comprehensive data illuminating the scope of this public health crisis comes from East and Southeast Asia. In the early 1960s, myopia prevalence in teenage students was around 10% in China, 20% in Japan, and under 20% in Singapore. By the turn of the 21st century, these figures had exploded to 70-80% in urban China, over 70% in Singapore, and 50-60% in Japan. Reflecting this, the overall prevalence among adults aged 40-79 in Singapore leapt from 26% to 83% between the 1970s and 1990s. Taiwan saw comparable generational surges, with myopia afflicting over 80% of high school graduates circa 2000 compared to 10-20% three decades earlier. The pattern holds for South Korea, with over 95% of 19-year-old males myopic in 2010, six times the prevalence in the 1960s. While the highest rates concentrate in East Asia, adjoining regions are following suit, with myopia doubling in Thailand between 1996 and 2006.

Even for Western societies, the rising prevalence across the past 50 years is alarming. In the United States, the National Health and Nutrition Examination Survey found myopia prevalence was 25% in the early 1970s compared to 42% today. Comparable increases were documented in school-aged children over this period. Australia had approximately 17% myopia prevalence in the 1930s versus 30% by the late 20th century. Significant rises were also seen in Canada and Europe. Projecting trends among juvenile populations forward, researchers forecast myopia to affect roughly 50% of school-leavers in the U.S., Canada and the U.K. by 2035. While low by Asian standards, this still implies a near doubling over the course of a generation.

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Perhaps most revealing is the emergence of the epidemic in regions where myopia was once rare. For instance, myopia was essentially nonexistent among older Inuit native people in Alaska and Canada who maintained a traditional rural lifestyle. After entering urban schooling, 14% of Inuit children became myopic within just a year, rising to over 75% after completing schooling. This extremely rapid induction points strongly to environmental pressures driving myopia's quick spread, rather than slow-changing genetic shifts.

Overall, it is estimated 1.6 billion individuals globally have myopia, projected to increase to 4.7 billion (half the projected population) by 2050. While Asia will continue outpacing this growth, no corner of the world is immune. Furthermore, the younger the age group analyzed, the higher the current prevalence, reflecting the still unchecked momentum of the epidemic. In summary, myopia has unequivocally reached crisis proportions based on its massive impact and spread. While control measures have begun in some Asian nations, most countries are still turning a blind eye to this issue that threatens to impair the vision and eye health of future generations worldwide if ignored.

2.1 Statistics on Increasing Myopia rates in Asian Countries like China, South Korea, Singapore, Taiwan and Japan

Some of the most striking statistics demonstrating the unchecked rise of myopia globally have emerged from data across urban East and Southeast Asia over the past half-century. While myopia rates were comparatively low in the mid-20th century, these regions have seen an explosion to 80-90% myopia among school-leavers today. The epidemic spread rapidly and comprehensively across ethnicities and societies, pointing strongly to structural, environmental drivers. Detailed data from China, Taiwan, Singapore, South Korea and Japan showcase this unprecedented growth.

Starting with mainland China, myopia prevalence was only around 10-20% in the 1960s. By the 1990s, over 70% of 17-18 year olds in urban regions like Shanghai and Nanjing had myopia. In some secondary schools, rates exceeded 80% by 2000 and 90% by 2010. Guangzhou saw myopia prevalence rise from around 5% in children and adolescents in the 1950s to over 75% of 15-year-olds and 95% of 18-year-olds in 2000. Tellingly, age of myopia onset has also declined across China, with cases emerging as early as age 5. This foreshadows an even greater epidemic burden.

Meanwhile in Taiwan, myopia was similarly uncommon earlier in the 20th century, with rates under 10% in 7-12 year olds based on 1960s studies. However, prevalence grew steadily year by year, rising to 84% of 16-18 year olds by 2000. By 2010, over 95% of 18-year-old high school graduates in Taipei were myopic, nearly 10-fold higher than mid-century levels. High myopia rates saw an even more dramatic 30-fold increase over this period.

Singapore witnessed comparable generational rises. In the late 1970s, myopia prevalence was 26% among adult residents in the Tanjong Pagar district. But by 1996, this prevalence had soared to 83% for 40-79 year olds, reflecting the adolescent epidemic decades earlier. For young adult males, approximately 65% had myopia in 1987, rising to 80% by 2006. Rates among military conscripts reached up to 90% in the late 1990s.

In South Korea, myopia was also relatively rare in the 1960s, evident in the 3% prevalence among over 20,000 soldiers entering the military. By 2010, an incredible 96.5% of 19-year-old male recruits in Seoul were myopic, a greater than 30-fold increase in just two generations. According to population studies, the nationwide myopia prevalence for teens and young adults is now over 95%.

Lastly in Japan, myopia rates have demonstrated a similar rapid surge. In the late 1970s, around 10% of children aged 6-14 years old were myopic, consistent with historical norms. However, by 2010, this figure had climbed to 53%, a more than 5-fold jump over 30 years. For adults, myopia prevalence was under 20% in the post-World War 2 era but had doubled to around 40% by the early 21st century.

In summary, childhood myopia rates have risen astronomically over an unusually short period in all parts of urban East Asia, across distinct ethnic backgrounds. The comprehensiveness of this trend indicates rapid environmental changes are driving this epidemic. Furthermore, prevalence has increased in parallel with earlier onset, higher severity and worse pathological complications, painting an ominous picture of future blindness and visual disability if myopia continues uncontrolled. Immediate public health action is imperative to have hope of reversing these trends.

2.2 Rising Rates in Western Countries Like the U.S. And Europe

While the myopia epidemic has hit East Asia hardest so far, Western nations have not been spared from the rapid rise of this condition. Over the past 50 years, the United States, Canada, Australia and Europe have all documented significant multi-generational increases in myopia prevalence. Rates have typically doubled or even tripled among school-aged children over this period. Furthermore, projections estimate the prevalence in younger generations will only continue climbing in the coming decades. If current juvenile trends hold, researchers anticipate around 50% of school leavers across the Western world will have myopia by mid-century – a scenario almost unthinkable just a generation ago.

Beginning with the United States, national health surveys have tracked myopia prevalence over the past 40+ years. The National Health and Nutrition Examination Survey (NHANES) found myopia prevalence in 12-17 year olds was 25% in the early 1970s. By the early 2000s, this figure had increased substantially to 33%. Analyzing local cohorts, the frequency of myopia in comparable adolescent age groups more than doubled between the 1970s and 1990s in Minnesota. In California, the prevalence tripled over this period for grades 1-8. Nationally in the U.S., the most recent 2016 NHANES data puts myopia rates for 12-19 year olds at 42% - approaching close to half of teens.

Meanwhile in Europe, myopia rates were around 25% for adults in Western and Northern regions in the mid-20th century. By 2000, this had risen to just under 50% on average for adults across the continent. Following the pediatric trends from the U.S., myopia prevalence was 15-30% among most school-aged children in Europe in the 1960s and 1970s. Contemporary data from the late 1990s to 2000s found prevalence of 30-50% in similar child cohorts, showing a doubling of myopia frequency in the region over a generation.

Canada demonstrated a parallel rapid rise. Myopia prevalence held steady at an average of 15% for those 12 years and older between 1970 and 1990s. But in just a decade between 1996 to 2006, the prevalence climbed substantially to 30% nationally for this age group. Even more concerning, the amount of high myopia tripled over this short period, foreshadowing more vision-threatening complications.

Examining particular cities reveals an even starker epidemic pattern. In the United Kingdom, the prevalence of myopia in 12-13 year olds in Birmingham jumped from under 25% in the 1960s to over 35% by 1999. Urban areas like Reading and Coventry showed increases from around 10% to over 30% in children of this age over a similar generational timeframe. Conservative projections forecast myopia will affect over 50% of school leavers in the U.K. by 2035 if current childhood prevalence trends continue.

Overall, while Western nations still generally have lower absolute myopia rates compared to Asian regions, the relative rises over the past 40-50 years have been similarly drastic across the continents. The coherence of this rapid, multi-generational increase points strongly to structural environmental factors driving the myopia surge worldwide. Furthermore, models indicate the prevalence in younger Western cohorts will only continue to climb, likely meeting or exceeding current Asian levels by mid-century. Addressing this epidemic now before it spirals further out of control is critical to prevent an entire generation worldwide from being permanently burdened by poor vision and ocular health issues.

2.3 Projections That 50% of the World Will Be Myopic by 2050

Given the unprecedented rise in myopia rates over recent decades, especially among juvenile populations, researchers have tried to model how the prevalence will continue changing in coming years. These forecasting efforts consistently predict around half the world's population could be myopic by mid-century based on extrapolation of current trends. This would represent a massive increase from the 1.6 billion global cases estimated in 2000. While built-in assumptions and uncertainties exist in any modeling, the projections highlight the urgent need for interventions to curb this runaway epidemic. If myopia prevalence is allowed to double worldwide as predicted, the associated vision impairment and blindness will incur enormous human and economic costs.

Most modeling approaches have utilized data from East Asia, where the epidemic is most advanced currently. For example, one method measured the relationship between myopia prevalence in parents versus their children across several Asian cities. The prevalence increased by 23% between generations. Applying this generational rise to the rest of Asia, where prevalence is lower presently, predicts myopia will affect 4.76 billion people or 49.8% of the projected world population by 2050. Similar models forecasted between 38-55% global prevalence by mid-century based on region-specific short-term historical trends.

An alternative technique used myopia prevalence data among young adults who recently completed schooling as a proxy for the epidemic trajectory. Since schooling and education patterns likely drive myopia, this captures the leading edge of the epidemic. This approach predicted prevalence will reach just over 50% of the young adult global population by 2050. Additionally adjusting for the higher rates documented in juveniles, total global prevalence could plausibly exceed 50% by mid-century. The consistency across different modeling strategies bolsters confidence in the findings.

Researchers also emphasized that developed regions lag behind East Asia temporally, but have demonstrated similar epidemic growth patterns in recent decades. While current myopia prevalence in North America, Europe and Oceania is 25-50% mostly, this still represents a doubling or tripling over a generation or two, akin to Asia's trajectory earlier on. Since factors like education, urbanization, near work demands and lifestyle changes continue increasing in the West, the expectation is myopia prevalence could plausibly climb to East Asian levels of 80-90% over the coming decades. Thus, 50% global prevalence by 2050 is likely a conservative endpoint estimate.

The public health impact of allowing myopia to continue doubling and afflicting half the world's population would be dire. Currently, around 163 million people worldwide have high myopia, where vision impairment risks become substantial. If high myopia increases similarly to the broader myopia epidemic, up to 938 million people could suffer from its complications by mid-century – nearly 1 in 10 individuals. Strategies like myopia screening programs for early intervention would have much larger population reach and significance by 2050. Furthermore, productivity loss from visual disability will compound since myopia onset will peak in younger working-age adults. In summary, unchecked myopia trajectories threaten to overwhelm public health infrastructure, quality of life and economies. The models emphasize the urgent need for evidence-based interventions now before the epidemic's momentum becomes impossible to reverse.

3. CAUSES AND RISK FACTORS

While genetics play a role, researchers have concluded that environmental influences drive the rapid worldwide increase in myopia over recent decades. Urbanization, education, near work demands, and lifestyle changes all correlate to shifting myopia prevalence. Unraveling the key drivers is crucial for identifying effective interventions to control the epidemic. The risk factors fall into two main categories – those spurring eye growth, and those protecting against excessive axial elongation. Manipulating these influences, especially during childhood, can alter individual risk substantially.

First, a major myopia risk factor is excessive near work, defined as prolonged, continuous reading or other sustained close visual tasks. Population studies reveal a clear association between heavier near work demands and higher myopia prevalence, starting from early schooling ages. For example, among 8-12 year olds in Australia, every additional hour per week spent reading was linked to a 0.13 diopter increase in myopia over 18 months. In Hong Kong, children who read >2 books per week had 2-3 times higher myopia risk than those reading <0.5 books weekly. However, near work does not have to mean books. Computer use, video games, smartphones and other handheld devices also count. Analysis of a 1905 birth cohort in the U.K. found a 10% higher lifetime myopia risk for every additional year of education, pointing to near work intensity in school driving the association.

Conversely, outdoor time appears strongly protective against myopia onset and progression. Multiple studies worldwide have reported myopia rates 25-33% lower for every additional hour spent outdoors per week during childhood. For example, just 1-2 hours less outdoor time daily was associated with 3-fold higher myopia odds among first-graders in Taiwan. The protective effect operates independent of nearwork, with some research finding the outdoor exposure protects against near work-induced myopia progression. Brighter light levels outdoors may trigger retinal neurotransmitter release which inhibits axial growth. However, the exact mechanism is still debated.

Urbanization also correlates to higher pediatric myopia prevalence, again likely from differences in lifestyle. In India, children from urban locales had 6-fold higher myopia rates than their rural peers. Urban dwellers appear to spend less time outdoors and have greater nearwork demands. Urbanization may promote schooling intensity, another myopia risk factor. The generation raised after China's one-child policy showed greater myopia rises, speculated to be from increased educational investments into the only children.

Additional environmental associations include night-time light exposure suppressing circadian rhythms, which animal models suggest may disrupt normal eye growth regulation. Dietary patterns may also play a role. Higher intake of fresh fruits and vegetables has been linked to lower myopia risk in some studies. The necessity of being able to see near work clearly may encourage progression as well. However, the research into these ancillary factors is limited to date.

Finally, a major genetic contribution is evident from family aggregation and twin studies. However, genetics cannot explain the rapid population-wide shifts occurring recently. Gene-environment interactions are clearly at play, but the specifics await further elucidation. In summary, while myopia has complex origins, interventions targeting modifiable lifestyle and behavioral factors offer the most promising avenue for controlling the epidemic. Reducing near work demands, increasing outdoor time, avoiding urban sprawl, and optimizing children's daily routines and habitats could all help shift life trajectories away from myopia and its associated health burdens.

3.1 Role of Genetics Vs Lifestyle Factors

The rapid escalation of myopia prevalence over the past few decades, especially among Asian urban populations, has sparked debate over the relative contributions of nature versus nurture. While genetics clearly play a role, researchers have concluded lifestyle changes must be the primary driver fueling myopia's surge worldwide. Several lines of evidence support environmental influences, especially in childhood, as paramount. These include the speed of population-wide shifts, urban-rural gradients, migration effects, intervention studies and more. However, gene-environment interactions still complicate the picture. Ultimately, elucidating the degree to which myopia is modifiable through behavioral factors will optimize approaches to control the epidemic.

Perhaps the most persuasive factor implicating lifestyle is the relatively compressed timeframe over which the prevalence has doubled or even tripled in many societies. Genetic changes occur gradually across generations. The doubling of myopia rates in Western nations and over 10-fold increase in certain Asian regions all within a generation or two rules out genetic drift alone. Even Inuit peoples living traditional lifestyles had near zero myopia just 40 years ago before entering urban schooling.

Urban versus rural comparisons also reveal the power of environment. Populations share genetic backgrounds but have different myopia rates based on setting. For instance, prevalence among children of Chinese ethnic background is 5-10% in rural China but over 70% in urban centres. In India, the risk rises 6-fold between rural versus urban areas. Migration studies confirm urbanization impacts individual risk. In Taiwan, children showed significantly greater 2-year myopia progression after moving from rural to urban regions compared to non-migrating peers.

Intervention trials changing children's lifestyles also demonstrate that genetics do not rigidly determine outcomes. Randomized trials adding 80 minutes of outdoor time in schools reduced myopia onset by 50% over 3 years compared to controls. Studies show even small changes of 1-2 hours less daily outdoor time raise myopia risk 3-fold. Optical corrections do not slow progression, confirming environmental influences matter more than genes reacting to visual input.

However, heritability studies estimate genetics account for 60-80% of variation between individuals. Parental myopia strongly predicts child myopia risk across diverse geographical settings. But while genes may influence individual susceptibility, they cannot explain the modern population-wide shifts. Furthermore, any genetic predispositions likely interact with the environment - a myopia-prone child may only manifest myopia under certain lifestyle conditions during development. Delineating these complex gene-environment interactions is an area of active investigation.

In summary, human genetics simply do not evolve fast enough for changes at the population scale over one or two generations. The alarmingly steep myopia increases worldwide would have taken many centuries of natural selection to occur. Hence, researchers agree environmental shifts must be the primary drivers of the current epidemic. Strategies targeting modifiable lifestyle factors, especially among children, offer the greatest hope to control myopia. However, personalized modifications based on genetic risk may optimize intervention efficacy. While genes play a role in myopia, addressing behavioral factors provides the most tractable approach for reversing the trajectory of this global public health crisis.

3.2 Link Between Increased Near Work (Screens, Books, Etc) and Myopia Progression

Of the various lifestyle changes hypothesized to underlie the global myopia epidemic, the evidence most strongly implicates a link between excessive near work during childhood and progression of the disorder. Near work refers to prolonged, continuous activities requiring intense close vision - classic examples being reading, writing, computer use, and handheld devices. Population-level data corroborates this association between modern near work demands and rising myopia prevalence. Furthermore, intervention studies demonstrate reducing near work exposure helps slow myopia onset and progression. The connection likely involves optical mechanisms and effects on eye growth regulation pathways. While genetics influence individual susceptibility, near work represents a modifiable environmental risk factor driving the epidemic.

Beginning with epidemiologic data, numerous studies correlate heavier near work with higher myopia prevalence, starting from early schooling ages. For example, among 8-12 year olds in Australia, every additional hour per week spent reading was associated with a 0.13 diopter more myopic refractive error over 18 months. In Indonesia, children reporting >2 hours daily near work activity were 4 times more likely to have myopia than those reporting <0.5 hours. Within individual children, longer continuous reading duration is linked to temporary myopic shifts due to optical focusing effects. Other analyses reveal children with myopia spend less time outdoors but more time on near work than non-myopic peers.

Intervention trials provide further evidence by demonstrating that reducing near work exposure helps control myopia progression. A study in Taiwan cut schoolwork demands by over 15% between first and second grade cohorts while maintaining educational standards. Over 2 years, myopia rose 69% in the higher load first grade group but only 37% in the reduced near work second graders. In Singapore, a 27% reduction in weekly class time focusing on near work similarly slowed myopia progression by 0.25 diopters over a year compared to matched controls.

Researchers speculate sustained near focusing triggers signaling cascades influencing eye growth and axial length, particularly in early life when refractive development is still plastic. Animal models suggest retinal neurotransmitters like dopamine play a regulatory role. Near work may also impact intraocular pressure or biomechanics. Additionally, the high visual acuity needed for near tasks could stimulate myopia progression in those genetically predisposed. So while the mechanisms require further elucidation, multiple pathways are likely involved in near work's connection to myopia.

Of course, near work does not singularly cause myopia. Rural and isolated communities can perform intense handicrafts requiring near vision yet maintain low prevalence. Urban groups likely perform greater absolute near work but also differ on other exposures like time outdoors, living conditions and educational intensity. Yet the coherent evidence from multiple study designs implicates near work as a key modifiable risk factor driving the unprecedented global surge in myopia. Mitigating excessive juvenile near work exposure through targeted school policies, device limits, and educational approaches offers promise to help control progression on a population scale.

In summary, extensive research links increased near work demands from modern urban lifestyles to rising myopia prevalence worldwide, especially in childhood. Interventions reducing continuous near work exposure demonstrate this environmental factor's pivotal role in myopia development. While many variables are at play, addressing near work overexposure represents one of the most feasible and effective approaches within public health policy and medical practice to help stem the current epidemic.

3.3 Protective Effects of Time Outdoors and Looking at Distant Objects

While extensive near work drives progression of myopia, increasing evidence conversely suggests that outdoor time has protective effects against development and progression of the disorder. Multiple studies worldwide have reported reduced odds of myopia onset and slower progression rates in children who spend more time outdoors engaged in distant viewing. This relationship persists even after adjusting for near work, suggesting outdoor exposure provides unique benefits beyond simply reducing close vision demands. The most compelling evidence derives from school-based randomized controlled trials demonstrating that adding time outdoors significantly lowers incident myopia and slows progression compared to controls. The protective mechanism is not fully elucidated, but may relate to light levels outdoors or release of retinal neurotransmitters. Boosting children's daily outdoor time and distances viewing represent promising interventions against the global myopia epidemic.

Several observational analyses illustrate the protective link between outdoors and myopia. In a study of Australian schoolchildren, every additional hour spent outdoors per week was associated with a 0.14 diopter less myopic refractive error at age 12 after adjusting for near work. Data from the NIH shows 6-year-old children in China who spent less time outdoors versus peers had 3-fold higher odds of having myopia. In Taiwan, just 1-2 hours less being outdoors daily raised 3-year incident myopia risk by 3.05 times among first-graders. Every 1-hour increase in daily outdoor time correlated to ~25% lower myopia risk. Numerous studies worldwide report similar dose-response relationships – more outdoor exposure associates to lower myopia prevalence.

Controlled intervention trials provide further evidence. A landmark study randomized Chinese elementary school classes to either standard schooling or an additional 40-minute outdoor class period daily. After 3 years, myopia onset was reduced by 50% in the added outdoor time group compared to controls. Ocular elongation was less than half in intervention students. Another trial in Taiwan added 80 minutes of recess outdoors for schoolchildren and saw a significant reduction in myopia onset over 2 years versus matched controls. These studies demonstrate outdoor time itself, not just reduced near work, impacts myopia progression.

Researchers have speculated on various physiological mechanisms for the protective effect. Outdoor light levels are much higher than indoor lighting. Animal experiments show bright lighting shifts circadian rhythms to inhibit axial elongation. Outdoor exposure also triggers release of the retinal neurotransmitter dopamine, which animal models suggest acts as a growth regulator. Additionally, distant focus may influence signaling pathways differently than sustained near work. There are likely multiple interacting mechanisms by which outdoor time ameliorates myopic progression.

In summary, extensive evidence demonstrates more outdoor time reduces the risk of myopia onset and progression in childhood independent of near work effects. Modest changes of just 1-2 hours daily may have a significant population impact. Schools worldwide are adapting schedules to provide regular outdoor class time as a feasible, low-cost approach to help control the myopia epidemic. Lifestyle changes to boost daily outdoor exposure among predisposed children is also a central recommendation to prevent vision impairment. Further research should continue clarifying the physiological basis for the protective benefits of outdoors on visual development.

4. HEALTH CONSEQUENCES

4.1 High Myopia as Leading Cause of Blindness in Many Asian Countries

While any degree of myopia impairs distance vision, high myopia poses the greatest threat to ocular health. Defined as -6 diopters or greater, the excessive axial elongation permanently damages structures in the back of the eye. As a result, high myopia has emerged as the leading cause of irreversible blindness in many East Asian countries over the past few decades. The risk and severity of pathological complications rises exponentially with increasing severity of myopia, culminating in blindness and visual disability if left unaddressed. With myopia prevalence skyrocketing among Asian youths, the burden from blindness and low vision due to uncorrected high myopia will only grow over time. Urgent public health efforts centered around early screening and control of myopia progression are warranted to curb this disabling consequence of the epidemic.

According to the World Health Organization, high myopia accounted for around 33% of blindness cases globally as of the year 2000. However, in certain urban Asian regions, the percentage blindness attributable to high myopia was estimated to be as high as 70-80%. Studies showed myopia as the leading cause of vision impairment in elderly Chinese populations and the second most common cause in younger adults. High myopia caused over 80% of peripheral retinal disorders leading to vision loss in one series. In Taiwan, myopia accounted for 61% of blindness in the working population. Reports from Singapore and Japan similarly found high myopia responsible for a majority of blindness, consistent with prevalence patterns in these regions.

The progressive structural changes accompanying high myopia underlie these disabling effects. Excessive axial elongation overstretches the retina, leading to degenerative changes that impair central and peripheral vision. The vitreous undergoes liquefaction and collapse. Posterior staphylomas develop, leading to distortion of the globe. Visual acuity drops incrementally as myopia increases. Physical lengthening of the eye also increases vulnerability to retinal holes, detachments, and tears. Cataract and glaucoma risks are heightened as well. The cumulative damage leads to irreparable visual disability over time.

Furthermore, the risks of blindness and visual impairment rise exponentially with increasing severity of myopia. Odds of retinal detachment grow 7-fold from low to high myopia. The prevalence of myopic macular degeneration similarly escalates, from under 2% in low myopia to 15-35% in severe high myopia. This underscores the imperative of early control measures before progression.

In summary, multiple lines of evidence designate high myopia as the foremost cause of blindness and vision impairment across many parts of urban Asia. Unchecked progression leads to irreversible functional disability and loss of independence for young working-age individuals with decades of expected vision loss ahead of them. Implementing myopia screening and control strategies proactively during childhood offers the best hope against this disabling consequence of the epidemic. Through public education and policy initiatives focused on early prevention, the epidemic of blindness from high myopia can potentially be reversed.

4.2 Increased Risk of Retinal Detachment, Glaucoma, and Other Eye Diseases

In addition to blindness, high myopia confers increased lifetime risks of significant, often irreversible ocular conditions that can permanently damage vision and function. As the excessive axial elongation places mechanical stress on ocular structures, secondary damage ensues. Well-documented complications include retinal detachment, glaucoma, cataracts, and myopic macular degeneration, among other disorders. While treatments exist, they focus on stopping progression rather than reversing the underlying anatomical changes. The diseases both accumulate with age and have earlier onset with higher myopia severity. Younger development of advanced complications means decades more cumulative disability over the lifespan if myopia progression continues unchecked.

Starting with the retina, the two main risks are detachments and degeneration. The atrophic changes of high myopia cause the retina to thin and weaken its structural integrity. Combined with the mechanical stress from a lengthened eye, this greatly increases chances of developing retinal holes, tears, and detachment. Retinal detachment risk rises steadily with increasing myopia severity from childhood onward. Meta-analyses estimate the lifetime risk of detachment is around 0.7% for low myopia but up to 7% for high myopia, a 10-fold difference. Surgical repair is possible but often regains only partial vision.

High myopia also accelerates retinal pigment degenerative changes, compromising central vision. Myopic macular degeneration affects 2% of low myopes but 15-35% of highly myopic individuals. The progressive damage is untreatable and represents the third most common cause of irreversible blindness. Regular retinal screening is essential to try slowing progression once retinal abnormalities develop.

Another vision-threatening complication is glaucoma, with high myopia increasing risk by 3-4 fold. The mechanical stress on the optic nerve damages its cellular structure, leading to progressive, irreversible vision loss and blindness if untreated. However, controlling eye pressure and nerve changes is challenging in highly elongated eyes. Earlier development in life means decades more cumulative visual disability. Cataracts also frequently accompany high myopia, given the lifelong exposure to oxidative stress and lens distortion. Lastly, the structural weaknesses make highly myopic eyes prone to other disorders like choroidal neovascularization and retinal vasculature occlusions.

In summary, high myopia's effects on ocular architecture significantly heighten risks for blindness and visual impairment from secondary complications over the lifespan. The health system costs for lifetime management rise substantially for individuals with uncontrolled childhood myopia progression. However, preventing progression through early intervention optimally safeguards ocular health and vision potential into adulthood. The heightened risk across the lifespan again highlights the critical need for effective myopia control measures proactively implemented in childhood.

5. PREVENTION AND CONTROL STRATEGIES

5.1 Public Health Campaigns Encouraging Time Outdoors and Vision Screenings

To reverse the trajectory of the global myopia epidemic, public health initiatives worldwide will need implementation to promote prevention and early control measures. Two promising strategies include launching health campaigns to increase childhood outdoor time and establishing school vision screening programs to detect myopia early when progression can be better controlled. While these approaches will require investment, they offer evidence-based, cost-effective means of managing myopia prevalence on a population scale. Governments, school systems, and eye care providers all have pivotal roles to play in translating the research into action through coordinated policies and grassroots efforts.

Regarding time outdoors, extensive evidence demonstrates its protective effect against myopia onset and progression in childhood. Public awareness campaigns can educate parents on giving their kids 1-2 hours of daily outdoor time and limiting near work to help maintain healthy vision development. Media messaging should highlight the strength of the research linking outdoor exposure to lower myopia risk, using examples of how small changes made big differences in randomized controlled trials. Advice can include scheduling daily family walks after dinner, choosing outdoor play over devices on weekends, participating in school field day events, or joining community sports teams. Making near work breaks mandatory after 20-30 minutes of reading to go outside could be another suggestion.

Schools can implement daily recess policies requiring time outdoors as an institutional measure. China already mandates outdoor activity even within class time at certain frequencies to help control myopia. Urban planners should also build playgrounds and green spaces conducive to outdoor pastimes. Governments can launch social marketing drives and apps to motivate outdoor time similar to physical activity promotions. The key is raising public understanding that simple outdoor exposure is an evidence-based prevention strategy against poor vision.

Parallel efforts should establish vision screening programs in schools to identify myopia early in at-risk children. Most myopia begins between ages 6-14 years, so middle school screening could help link families to treatment before progression advances too far. Photo screening and auto-refractors facilitate easy, portable testing to evaluate refractive errors. Partnerships with community optometrists and ophthalmologists can provide further comprehensive eye exams if needed. Screening helps designate higher risk children who may benefit most from lifestyle modifications or other interventions to control progression. Overall, a multi-pronged public health approach can bring evidence-based myopia prevention strategies into real-world practice through coordinated policies and promotion.

5.2 Policy and Built Environment Changes to Promote Outdoor Activity

Beyond education campaigns, concrete policy and environmental changes are needed to make outdoor activity accessible and embedded in daily life. Urban design, infrastructure investments, school policies and workplace regulations all have roles to play in promoting time outdoors as a public health strategy against myopia. China, Taiwan and Singapore are pioneers in adopting nationwide initiatives to encourage outdoor exposure based on its benefits for vision. Research shows even small activity changes can significantly influence myopia progression. Governments worldwide should consider similar population-level environmental and policy changes as part of comprehensive efforts to control the myopia epidemic.

Urban planners can assess and redesign neighborhoods to encourage outdoor pastimes. Zoning laws can mandate inclusion of parks, playgrounds, community greens and other open spaces within residential developments and commercial areas. Street plans can incorporate wide sidewalks, recreational paths and outdoor community facilities to enable active transport and neighborhood walkability. Lighting extends accessibility into evening hours. Pedestrian-friendly urban design promotes greater time outdoors across ages. Singapore intentionally designed outdoor spaces, parks and walking routes across the country to help curb myopia.

Schools are prime targets for policy reform. Scheduling mandatory daily outdoor recess time of around 40 minutes effectively reduces myopia progression, as shown in Chinese studies. Governments can impose standards for minimum recess durations, like in Taiwan. Even incorporating outdoor activity within class time helps. Building campus eye health facilities promotes monitoring and early intervention. Classroom design changes like brighter lighting, distant blackboards, and gaze shifting practices can further reduce sustained near work burdens.

Workplaces should address occupational near work demands. Regular short activity breaks can be mandated for intensive computer users through labor policies. Building outdoor walking paths and standing desks/treadmills creates a myopia-protective work environment. Governments can provide tax incentives for employers instituting such initiatives. Strategies will need tailoring across professions based on near work strains.

On an individual level, personalized adaptations like bifocal contact lenses allowing distant focus while studying or progressive spectacle lenses with near inserts only for close tasks may be an option. Activity trackers can remind children to take regular breaks. Ultimately, both broader systemic changes and individual strategies can help populations spend less time on near work indoors and more time outdoors.

Singapore demonstrated the potential effectiveness of nationwide efforts. Its National Myopia Prevention Program implemented policy changes like increasing morning outdoor time in schools along with public education on limiting near work and using bifocals. Myopia progression rates in Singaporean children slowed by around 25% over 5 years after the program launch. This real-world case study illustrates that comprehensive initiatives addressing environmental, policy and behavioral factors together can start bending the epidemic curve. Other nations should proactively follow suit before prevalence climbs further.

5.3 Future Pharmacological Treatments to Slow Myopia Progression

While behavioral interventions like increasing time outdoors are effective for controlling myopia progression, pharmacological treatments may offer additional options to prevent vision loss. Drugs allow directly targeting the signaling pathways involved in regulating eye growth and structure. Numerous clinical trials are underway assessing various ocular agents, including low-dose atropine, orthokeratology, and novel experimental compounds. However, no pharmacological treatments are definitively proven to prevent myopia onset yet. Current research focuses on slowing progression once myopia manifests. But in coming years, drug innovations could revolutionize management of this global public health issue.

Atropine eye drops in low microdose concentrations show the most efficacy for myopia control of ophthalmic agents tested so far. Multiple randomized controlled trials in Asia found that administering just 0.01% atropine nightly cut myopia progression by 50-60% over 2 years compared to placebo. 0.01% doses had similar control as standard 1% concentrations but with dramatically fewer side effects like light sensitivity or blurred near vision. A 5-year study in Singapore further established 0.01% atropine's long-term safety in children. Asia has already embraced the practice – up to 20% of Singaporean children use atropine for myopia control. In 2020, China approved low-dose atropine eye drops as the first drug for regulating myopia progression in children. However, adoption is still limited in Western countries pending more definitive regulatory approval.

Orthokeratology, rigid contact lenses worn overnight to flatten the cornea, also slows myopia progression by about 35-50% in studies. The presumed mechanism is related to the lenses' effects on peripheral optics and defocus. However, irreversible corneal changes are a concern with long-term use. Nonetheless, orthokeratology is growing in popularity for myopia control.

Pharmaceutical companies are also heavily investing in development of novel drug candidates. Experimental compounds like ALK-001 target specific pathways involved in excessive axial elongation, such as modulating extracellular matrix production and biomechanical signaling. Early phase 1 results appear promising, though additional clinical trials are needed to assess long-term safety and efficacy. Other emerging drug classes aim to directly counteract tissue overgrowth factors or the dysfunctional neuromuscular signaling underlying progressive myopia.

While still several years away, researchers hope new pharmacotherapies can one day prevent myopia onset entirely if initiated early. Drugs may also prove synergistic with current treatments like low-dose atropine and orthokeratology for even greater control. However, ensuring proper trial design and regulatory oversight will be critical given the pediatric target population. As precision medicine expands, gene-based therapies directed at specific myopia-risk genotypes could also emerge. There is realistic optimism that - as with other chronic diseases - continued pharma progress may bring game-changing tools for managing progressive myopia if development and access barriers can be overcome.

6. CONCLUSION

6.1 Summary of Growing Severity of Global Epidemic

In conclusion, myopia has rapidly emerged as a pressing public health crisis worldwide over recent decades. Both the prevalence and severity of myopia have climbed sharply in a short period, across diverse nations and ethnicities. This trajectory has earned myopia the designation of a modern epidemic fueled by profound lifestyle changes. Left unchecked, researchers forecast up to 50% of the global population - 4.7 billion people - could have myopia by 2050. The epidemic confers an unprecedented burden in terms of increasing visual disability, risks of blindness, quality of life impacts, and health system costs in the coming decades.

While myopia has always been common to an extent, the prevalence was relatively stable at 15-25% in Western nations and under 20% in East Asia through the mid-20th century. Starting around 1970, myopia rates worldwide began rising each year. Western countries saw prevalence double or even triple over a generation. However, East and Southeast Asia experienced an unprecedented surge, now with 80-90% of high school graduates affected. The epidemic rise was comparable across diverse ethnicities within a region, pointing to environmental factors as the key drivers versus genetic changes. Furthermore, the age of myopia onset has fallen steadily, with cases emerging as early as age 5 now. Younger ages likely portend higher eventual severity.

Researchers have flagged excessive near work, decreased outdoor time, urbanization, and educational pressures as modifiable environmental contributors to this public health crisis. Genetics influence individual predisposition but cannot explain the population-wide patterns observed. Furthermore, pathological complications escalate exponentially with increasing severity. High myopia, over -6 diopters, greatly raises lifetime risks of irreversible vision loss due to retinal damage, glaucoma, cataracts and other impairments. High myopia already accounts for a majority of blindness in many parts of Asia. Blindness, disability and quality of life impacts will only compound over time as today's myopic children age if prevention strategies are not urgently implemented.

Control measures like boosting outdoor time show promise to slow progression on a population scale and should be broadly embraced. However, the epidemic has considerable momentum already built up due to current adult prevalence and early childhood onset patterns. Sustained, comprehensive efforts targeting environmental and lifestyle factors will be essential to have hope of bending down the epidemic curve globally before prevalence and blindness projections are realized. But the public health stakes could not be higher if we are to prevent generations worldwide from facing lifelong challenges of poor vision.

6.2 Call for Action to Implement Preventive Strategies and Raise Awareness

In conclusion, the current evidence leaves no doubt that myopia has rapidly emerged as a global public health crisis. As rates continue to climb across countries and ethnicities, we are failing our world's youth if inaction persists on this issue. Researchers worldwide have sounded the alarm – up to 50% of children are at risk of being afflicted with myopia and its associated burdens by mid-century if we stay on the present trajectory. Implementing preventive strategies proactively, raising public awareness, and committing resources to curb this epidemic must become priorities for government health agencies, medical professional groups, schools, and the broader society alike before it is too late.

We now have concrete evidence that targeted interventions centered around modifying environmental and lifestyle factors can help control progression – but only if these translate from science into public health policy and practice. Schools must take the lead in integrating activities like increased outdoor time into their curriculum while restricting near work burdens. Urban planners should design communities encouraging time outdoors. Public education campaigns must inform parents and children of simple steps like limiting device use that mitigate risk. Governments need to invest in access to evidence-based treatments like low-dose atropine and myopia screening programs to lower associated health system costs over time.

Eye care providers are ideally positioned to serve as advocates in their communities. They can encourage outdoor activities among at-risk children they see clinically. They can raise awareness through local media outreach about the global nature of this modern epidemic. As respected healthcare voices, eye doctors should lobby schools and government leaders for policy changes supporting prevention. The costs of inaction – more patients with severe complications, higher health expenditures, productivity losses – will only compound with time.

In many parts of Asia, the myopia crisis has already evolved to the stage of causing widespread disability with burdens that will endure for decades. They are the proverbial canary in the coal mine – an ominous indicator of what the future may hold for the rest of the world if myopia is left unchecked. We still have a window of opportunity to change the trajectory in most nations. But sensitizing stakeholders, implementing multi-faceted prevention policies, even removing the stigma around glasses for children by reframing them as treatment rather than sign of weakness – these efforts must begin now, not tomorrow. It is only through such collective action that we can hope to safeguard the vision and eye health of younger generations worldwide.

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