Light and the Aging Eye

The Power & Importance of Lighting to our Aging & Low Vision Populations & the Facilities That Support Them.

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Abstract

Quantity and quality of light are the crucial elements for everyone's well being but more so for the low vision population. Lighting design has always functioned around a baseline set of recommended practices presented by the Illuminating Engineering Society in its Lighting Handbook. These recommended practices and standards are widely accepted and applied but often without regard to one important qualifier. The recommendations presented are historically based upon the needs of normally sighted people and normal environmental conditions.

This presentation examines how lighting can be used to support vision, mental and physical health and quality of life for those with aging eyes or low vision in the various facilities that cater to these populations. The number of persons aged 65 years or older is expected to increase from approximately 40 million in 2010 to an estimated 71 million in 2030, roughly 20 percent of the U.S. population. This older population's growth will impact many industries with particularly great demands placed on building design and healthcare. However, few people have considered the potential impact lighting can have upon the aging population's health and quality of life. Proper lighting conditions can help increase personal independence, improve productivity, promote better health and increase safety, all of which have a direct impact on business profits, care giving costs and quality of life. In the latest round of vision research, direct correlations between the quality of illumination and a person's quality of life are supported. These biological effects of light are an indispensable health factor that should be part of our lighting design decisions, just as good nutrition is part of any good health policy. We will touch on what an aging visual systems means to both the occupant and designer, where the latest research stands on our psychological and physiological connections to light, how both of these intersect to influence a path to lighting design solutions that can respond to the aging eyes requirements and the current efforts to include low vision requirements in our various building codes and recommended practices.

Introduction

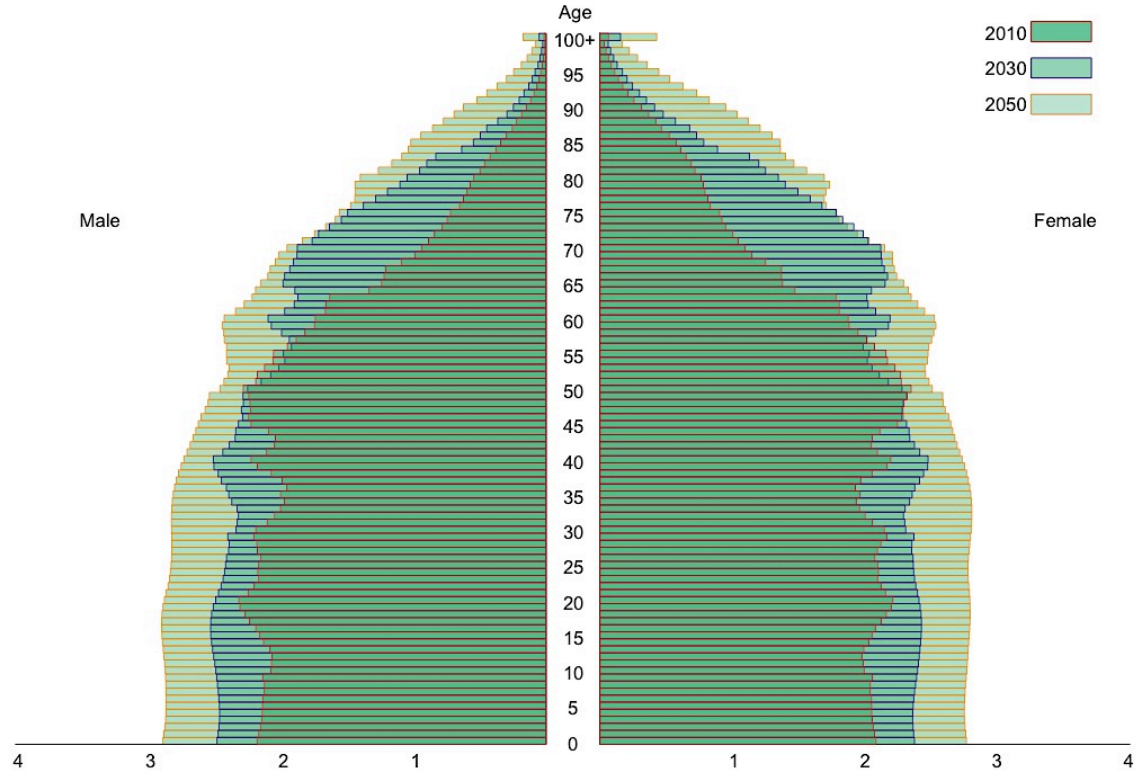
The lighting design industry is moving steadily toward more comprehensive recommended practices for those with low vision. One of the many issues we face is a lack of coordination between the development of these recommended practices and the various building codes, regulations and guidelines our industry must follow. The development cycles of these items are often slow, political and fraught with special interests. True progress can only occur when the development industry as a whole recognizes that it is imperative we move beyond a focus of just mobility and address sensory loss and health with coordinated code requirements that are supportive of qualitative recommended practices. A good example of these efforts are the upcoming changes to the ASHRAE/IES 90.1 energy standard that provide specific enhanced requirements for senior care facilities that recognize the additional lighting needs of that population. Although this increase was made for limited space types, this action paves the way for broader changes to the various building codes in an effort to support the low vision population and eventually all people by encouraging the design of healthy spaces.

Aging and Vision

It's hard to ignore the drumbeat from all corners telling us about the 'Silver Tsunami' that is looming. The number of persons aged 65 years or older is expected to increase from approximately 40 million in 2010 to an estimated 71+ million in 2030, roughly 20 percent of the U.S. population.

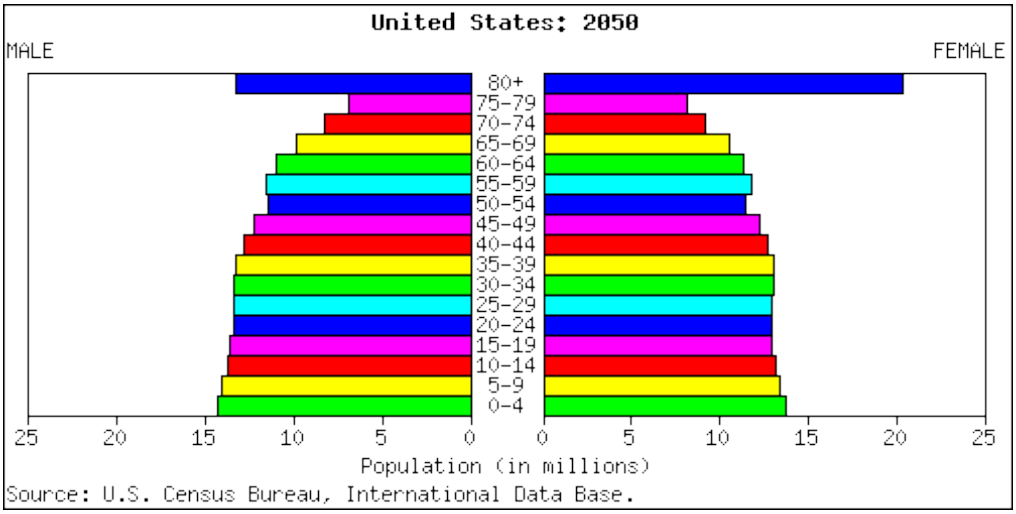
- Population aged >=65 years
  - from 12.4% in 2000 → 19.6% in 2030
  - 35 million in 2000 → 71+ million in 2030
  - roughly 20 percent of the U.S. population
- Population aged >=80 years
  - from 9.3 million in 2000 to 19.5 million in 2030

Figure 6. Age and Sex Structure of the Population for the United States: 2010, 2030, and 2050
2008 National Projections
(In millions)



Source: U.S. Census Bureau, 2008.

By 2050, the single largest age group in the country is estimated to be 80+, and not by a small margin. This older population's growth will impact many industries with particularly great demands placed on building design and healthcare.



However, few people have considered the potential impact lighting can have upon the low vision population's health and quality of life. The low vision population includes not just the aging, but those of all ages that access every type of facility. Proper lighting conditions can help increase personal independence, productivity, promote better health and increase safety. All of which have a direct impact on care giving costs, facility operational costs and quality of life. It should be noted that while these types of discussions are often focused on our aging population, the fundamental principals apply to all age groups and all facility types. Low vision does not discriminate and is therefore a very broad population that must be considered in truly inclusive design.

"The biological effects of light are an indispensable health factor."

"Optimum light exposure ought to be as uncontroversial an aim of future health policy as best-possible nutrition. The appreciation of daylight can be understood better when the biological effects of light are known."

Professor Wolfgang Ehrenstein

Of course, our population continues to age, it stands to reason that the incidences of vision loss and low vision will continue to increase. According to Prevent Blindness America, in 2010 nearly 1.3 million Americans 40 and over reported being blind and another 2.9 million reported having vision impairment (20/40 vision or worse). These two statistics don't include instances of Age Related Macular Degeneration, Cataract, Diabetic Retinopathy, Glaucoma, etc. Looking at those numbers tells an even more troubling story of an already immense population of aging

Americans with vision disease that will only compound the natural degradation of their visual system.

2010

state	vision problem	race	sex	age	number of cases
UNITED_STATES	AMD	ALL	ALL	40 and older	2,069,403
UNITED_STATES	BLINDNESS	ALL	ALL		1,288,275
UNITED_STATES	CATARACT	ALL	ALL		24,409,978
UNITED_STATES	DIABETIC_RETINOPATHY	ALL	ALL		7,685,237
UNITED_STATES	GLAUCOMA	ALL	ALL		2,719,379
UNITED_STATES	HYPEROPIA	ALL	ALL		14,186,819
UNITED_STATES	MYOPIA	ALL	ALL		34,119,279
UNITED_STATES	VISION_IMPAIRMENT	ALL	ALL		2,907,691

Prevent Blindness America

To understand how this occurs and how it relates to lighting design and our built environment, we must look at some of the more common clinical problems we encounter as we age and what effect that has on our visual system. For the sake of this discussion, these factors fall into two categories. The first being natural, non-disease, age related characteristics that degrade our vision as we age, and the second is the disease component.

- The clinical problems as we age:
  - Natural age related issues
    - Reduction in retinal photoreceptors (Rods)
    - Lens hardens (Presbyopia)
    - Lens yellows (Opacification)
    - Pupil gets smaller (Pupillary Miosos)
    - Floaters
    - Dark adaptation slows (Delayed rhodopsin regeneration)
  - Disease
    - Cataracts
    - Glaucoma

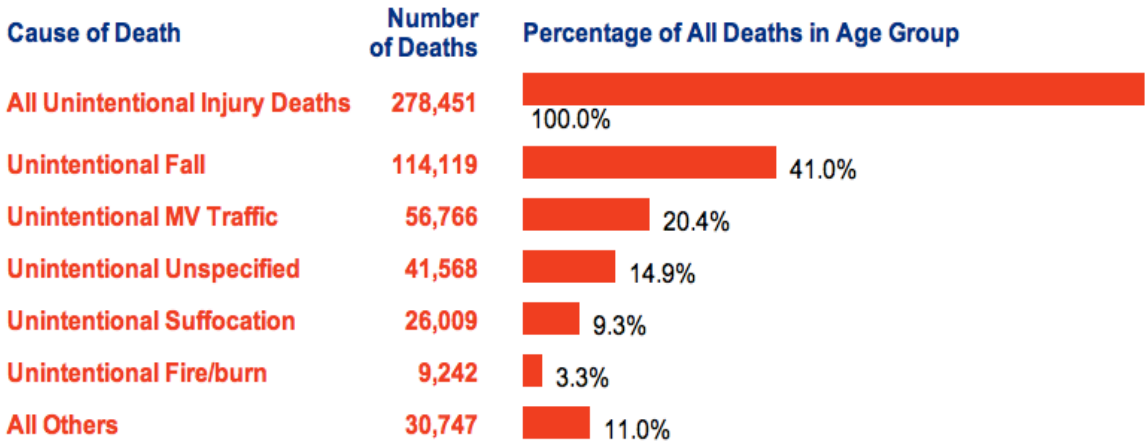
- Retinal Detachment
- Age Related Macular Degeneration
- Diabetic Retinopathy

What do all of these have in common? First, there is a reduction in the amount of light that can enter and be effectively used by the eye. Second, is an increase in the amount of light scatter within the eye causing a greater likelihood of, or sensitivity to glare. Finally, primarily due to the yellowing of the eye's lens, a reduction of blue wavelengths entering the visual system occurs. These three results are the keys to understanding how we can tune lighting systems to support good health, safety and quality of life.

Health and Safety

Safety alone can become quite a challenge. According to the Centers for Disease Control and Prevention, of the five leading causes of unintentional injury deaths in the United States for the ages 65-85 from 2000-2007, unintentional falls is number one, accounting for 41% of all deaths caused by an unintentional injury.

5 Leading Causes of Unintentional Injury Deaths, United States 2000 - 2007, All Races, Both Sexes Ages: 65-85



Centers for Disease Control and Prevention

While trips and falls are often the most discussed hazards, low vision and inadequate lighting can also contribute to issues with medication dosing, impaired concentration and learning, and decreased productivity, to name a few.

According to the American Federation for the Blind, at the top of the list of public health fears for Americans is vision loss (21%). Americans say their biggest concern about low vision is losing their ability to live independently. The result of this can have quite a psychological impact resulting in depression, stress and anxiety.

Vision, sleep and neuroscience research along with in-the-field design work over the past decade has also shown direct correlations between the quantity and quality of illumination and a person's health. Studies such as the *Effect of Bright Light and Melatonin on Cognitive and Noncognitive Function in Elderly Residents of Group Care Facilities*[1] show short and long term effects of lighting as a circadian stimulus. Typical exposure to indoor lighting in facilities that cater to an older population is shown to create what is called a low 24hr amplitude or fragmented circadian cycle. This is in turn is linked to a whole host of physical and psychological problems as our circadian cycle is tied to over one hundred timed bodily functions such as blood pressure, sleep and hormone secretion.

Circadian Disruption – Fragmented Cycles (*low 24-hr amplitude)*

- Poor sleep** and higher stress (Eismann et al., 2010)
- Increased anxiety and depression (Du-Quiton et al., 2009)
- Increased smoking (Kageyama et al., 2005)
- Cardiovascular disease (Young et al., 2007; Maemura et al., 2007)
- Type 2 diabetes (Kreier et al., 2007)
- Higher incidence of breast cancer (Schernhammer et al., 2001; Hansen, 2001)

While the above noted study focused on an older population, other studies looking at healthy, active adults under the age of 65 have shown that light exposure and time of day can have a significant health impact. Two independent epidemiologic studies by Davis et al.[2] and Schernhammer et al.[3] provided compelling evidence supporting the hypothesis that exposure to visible light at night was suppressing melatonin production and therefore potentially increasing the risk of breast cancer. Studies like this have prompted the World Health Organization to list shift work as a probable carcinogen.

[1] Journal of the American Medical Association, Vol. 299. No.22, pp 2642-2655.

[2] Davis S, Mirick DK, Stevens RG. Night-shift work, light at night, and risk of breast cancer. J Natl Cancer Inst 2001;93:1557–62

[3] Schernhammer ES, Laden F, Speizer FE, Willett WC, Hunter DJ, Kawachi I, et al. Rotating night shifts and risk of breast cancer in women participating in the Nurses' Health Study. J Natl Cancer Inst 2001;93:1563–8.

Physical and psychological wellbeing is important for any population but clearly, as we age, low vision poses an immense and increased risk. These risks have a direct impact on quality of life and care giving costs for everyone.

A Path To Solutions

In response to this information and the exponential growth of the low vision population, the lighting design community has begun to develop new as well as revising existing recommended practices and guidelines. The two primary examples of this are the recent revision of the Illuminating Engineering Society's *Lighting Handbook* now in it's 10th Edition and the continued development of the ANSI/IES RP-28 *Recommend Practice for Lighting and the Visual Environment for Seniors and the Low Vision Population.* The Lighting Handbook has again divided its illuminance recommendations into three age categories, 25 and under, 25-65 and 65+. While its recommendations are still based upon someone with "normal vision", this format at least begins to recognize basic age related visual needs. As the defacto industry standard for lighting recommended practice, this opens the door to greater awareness and design accommodation. The ANSI/IES RP-28 document takes this further by specifically addressing low vision needs in facilities designed primarily to support the older population. The recommended practice has become one of the standards referenced in the 2010 FGI *Guidelines for Design and Construction for Health Care Facilities* adopted by 43 states as a part of their regulations for senior care environments.

This ongoing progress being made is encouraging and has a great deal of support from all sides of the lighting and building industry. The problems begin to occur at the implementation level when these recommended practices are brought to the table with current building codes and regulations. Energy codes have developed aggressively with a single-minded quantitative focus on efficiency making it challenging to achieve the enhanced lighting being called for. Add to the mix a green building requirement that is designed to accomplish an additional level of efficiency beyond the energy code, and designers quickly find their ability to achieve a quality visual environment, as recommended, a serious concern. Finally, old entrenched lighting requirements in building codes such as life safety minimum egress illumination levels do not reflect the low vision population's needs but continue to be difficult to update. This tug-of-war between recommended practices for those with low vision and building codes continues to be a back and forth battle. Fortunately, it is one that most believe is important to address as evidenced by the latest changes being proposed for the next revision of 2013 ASHRAE/IES 90.1 *Energy Conservation in New Buildings Except Low-Rise and Residential Buildings.* The proposed changes will, for the first time, define a set of senior care, low vision and healthcare facility types and provide a separate set of Lighting Power Densities reflecting the higher recommended illuminance values for these buildings and their typical population. In addition, the 2014 edition of the FGI *Guidelines for Residential Care Facilities: Design and Construction of Residential Health, Care, and Support Facilities* will continue its progress by adding information on the visual environment, including light reflectance values, value contrast and surface finishes (sheen or gloss). Groups such as Illuminating Engineering Society's Lighting for Aging and the

Partially Sighted committee and the National Institute of Building Sciences Low Vision Design committee, are working with various organizations to facilitate changes like this and bring greater awareness.

Comparison of LPD ($W/ft^{2)}$ in Typical Spaces and Senior Care:

Space type:	Typical	Senior Care
Dining/Activity Areas:	.65	2.65
Living Room/Recreation:	.73	2.41
Corridors:	.66	.92
Lobbies:	.90	1.80
Restrooms:	.98	1.21
Chapel :	1.53	2.21

The next question to answer is, what do we do with this information and how can we effectively apply these new recommended practices? The answer is simple but the application not so. Our goal is to mimic what nature already provides; cool bright days and warm dim evenings. Our path to a design solution lies within an integrated design theory. Integrated design is certainly not something new but the result we are trying to achieve is still fairly uncommon. Our focus should be a “Tunable Lighting Environment”. This means more than adjusting light levels with a dimmer. To create this supportive environment we must consider the balance between the architectural characteristics such as color, value contrast and reflectance values combined with daylighting, multi-layered artificial lighting, circadian optimized lighting and controls. The result needs to not only accomplish our traditional lighting goals but also place a greater emphasis on the appropriate spectral distribution, luminance and illuminance for the given time of day. All of this while maintaining good control over contrast and glare. It’s surely no small feat that requires a greater level of design team coordination and effort. We have a great number of tools at our disposal and the economics improve constantly. These tools get more advanced every week as technology charges ahead. For example, we are already seeing LED lighting fixtures capable of tuning their spectral distribution. This type of advanced tool can allow a designer great flexibility with minimal equipment overhead. LED and OLED lighting and highly customizable controls continue to improve, holding great promise for easier, lower power and more cost effective opportunities. Design tools are also improving allowing us to better plan and predict the visual environment by calculating luminance and illuminance values as well as studying daylighting and shading solutions.

Conclusion

Light is for people. If we are not supporting all people with quality illuminated environments, then that light is inherently wasted. It should be our hope and goal that in the future no one will think that they have to compromise the quantity and quality of light for any population for the sake of energy conservation or any other reason. Efficient, healthy and supportive environments should be "as uncontroversial an aim of future health policy as best-possible nutrition"[4]. Until that day comes, we need codes and regulations that protect the independence, health and safety of our low vision population and practitioners willing to make qualitative design a priority.

[4] Professor Wolfgang Ehrenstein