

A Survey of Licensed Wisconsin Optometrists on  
Lutein and Zeaxanthin and Eye Health

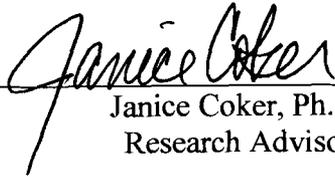
by

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ABSTRACT

Age-related macular degeneration (AMD) and age-related cataract (cataract) are two of the leading causes of vision impairment and blindness in the U.S. (Prevent Blindness America, 2002). The rate of vision impairment and blindness is expected to double in the next 30 years. Lutein and/or high-dose antioxidants reduce(s) the risk of AMD or improve(s) visual function in patients with AMD (Seddon, Ajani, et al., 1994; Age-Related Eye Disease Study Group [AREDS Group], 2001a; Richer et al., 2004).

The purpose of this study was to determine the perceptions, recommendations, and educational or informational materials of optometrists on lutein and zeaxanthin and eye health. A 20-item survey was developed and mailed to 300 randomly chosen licensed optometrists in Wisconsin. The response rate was 42.3%.

Most respondents (77.2%) were moderately to very informed about the relationship between lutein and zeaxanthin and eye health. The information on lutein and zeaxanthin and eye health was adequate for 78.0% of respondents to make recommendations to patients. A multi-vitamin/mineral supplement was the most recommended supplement (91.3%) with a lutein or zeaxanthin supplement (86.6%), spinach or other foods rich in lutein and zeaxanthin (85.8%), and a zinc supplement (85.0%) following closely behind. Most respondents distributed educational or informational materials to patients at their practice (79.5%) while about half (50.5%) of these respondents had educational or informational materials on lutein and zeaxanthin.

An increased demand from patients and insurers to provide nutrition education is anticipated. Patient educational materials or dietitian referrals are key strategies to provide this education. Future research should address the barriers of optometrists in obtaining information on nutrition for eye health.

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## Chapter I: Introduction

Vision impairment and blindness due to age-related eye disease is increasing (Prevent Blindness America, 2002). Age-related macular degeneration (AMD) is the leading cause of blindness in persons age 60 and older in the U.S. while cataract is the leading cause of blindness in the world (National Eye Institute [NEI], 2002, March). Blindness negatively affects both an individual's quality of life and the national economy (Prevent Blindness America). The carotenoids lutein and zeaxanthin may play a preventive role in age-related blindness as discussed below.

Lutein and zeaxanthin are the only two carotenoids concentrated in the macula (Snodderly, 1995) and lens of the eye (Yeum, Taylor, Tang, & Russell, 1995). These two yellow plant pigments are called the macular pigment (Pratt, 1999). Macular pigment density (MPD) is positively associated with visual acuity (Hammond, Wooten, & Snodderly, 1998) and inversely associated with lens optical density (LOD) (Berendschot et al., 2002). Studies have shown that MPD can be increased through diet (Hammond, Johnson, et al., 1997) or supplementation (Landrum et al., 1997; Berendschot et al., 2000). A higher dietary intake of spinach or collard greens, foods rich in lutein and zeaxanthin, has been associated with a lower risk of AMD (Seddon, Ajani, et al., 1994). Brown et al. (1999) and Chasan-Taber et al. (1999) found a 19% and 22% lower risk for cataract extraction in men and women, respectively for those with the highest intake of lutein and zeaxanthin intake compared to those in the lowest quintile.

In addition to reducing the risk of AMD and cataract, lutein, zeaxanthin and/or antioxidants have reduced the risk of progression to advanced AMD (AREDS Group, 2001a) and have improved visual acuity in AMD patients (Richer et al., 2004). This has led to the

manufacture of lutein and zeaxanthin as a dietary supplement (Kreuzer, n.d.) and to lutein as the most popular herbal and other natural dietary supplement mainly in the form of a multi-vitamin preparation (Kelly et al., 2005).

Natural sources of lutein and zeaxanthin include kale, collard greens and spinach as the highest sources (United States Department of Agriculture [USDA], n.d.). Healthy People 2010 (Food and Drug Administration [FDA] & National Institutes of Health [NIH], 2000) and The Dietary Guidelines for Americans (United States Department of Health and Human Services [USDHHS], 2005) both recommend frequent consumption of dark green vegetables. Despite the 5 A Day guidelines (National Cancer Institute [NCI], 2001), most Americans are not meeting the recommended number of fruit and vegetable servings (Centers for Disease Control and Prevention [CDC], 2006; FDA & NIH). The Multi-Center Eye Disease Case-Control Study found a median intake of 1.7 mg lutein per day (Seddon, Ajani, et al., 1994) while 6 mg per day has been shown to reduce risk for AMD (Mares-Perlman et al., 2001). The increasing rate of AMD and cataract may possibly be affected by the low consumption of dark green vegetables with lutein and zeaxanthin.

Although the role of lutein in prevention of age-related eye disease is still uncertain (NEI, 2002, July), optometrists can promote the intake of dark green vegetables as it is a national public health objective (FDA & NIH, 2000). With their expertise in eye care, optometrists are uniquely positioned to provide nutrition education for eye health. They may also provide credible information to guide patients on the use of nutritional supplements for eye health. With optometrists' lack of financial incentive and time for preventive health care, educational or informational materials or a referral to a dietitian may be an effective way to promote a healthy diet and address patient nutritional concerns.

### *Statement of the Problem*

Studies showing a relationship between diets high in lutein and zeaxanthin and eye health along with an increased popularity of lutein supplements have provided a challenge for optometrists to take on a non-traditional role of nutrition education. The purpose of this study was to describe how the confidence of licensed Wisconsin optometrists in the relationship between diets high in lutein and zeaxanthin and eye health influenced their clinical practice. First, this study was conducted to gain an understanding of how optometrists viewed the current state of literature on nutrition and eye health. Secondly, since it is most likely that patients would seek out nutrition advice for eye health from their eye doctor, knowing the nutritional recommendations of optometrists can assist patients in obtaining credible information. Third, patient educational materials can compliment advice given in the office. Assessing the availability and perceived importance of educational materials can help public health professionals determine the need to develop these materials.

### *Research Objectives*

The specific research objectives were to:

1. Evaluate the awareness, sources of information, and confidence of Wisconsin optometrists on the relationship between diets high in lutein and zeaxanthin and eye health;
2. Determine the nutritional recommendations of Wisconsin optometrists for the prevention or treatment of AMD and cataract;
3. Assess the availability and importance of educational materials on lutein and zeaxanthin to Wisconsin optometrists;

4. Summarize the perceptions of Wisconsin optometrists of lutein and zeaxanthin and eye health; and
5. Describe the demographic characteristics of Wisconsin optometrists.

### *Assumptions of the Study*

It was assumed that optometrists who completed the survey were honest in their responses and that their answers reflected their current practices and feelings.

### *Definition of Terms*

*Snellen Chart*: Chart containing rows of letters, numbers or symbols of a standardized size used to test visual acuity usually at 20 feet (Triad Publishing Company, 2006).

*20/20 vision*: Normal sharpness or clarity of vision (visual acuity) at a distance of 20 feet. This is only one indicator of visual function. Other indicators include side vision, eye coordination, depth perception, focusing ability and color vision (American Optometric Association [AOA], 2006b).

*Vision impairment*: Vision of 20/40 or worse in the better eye with best correction (Prevent Blindness America, 2002) often referred to as low vision (The Eye Diseases Prevalence Research Group [EDPRG], 2004a).

*Legal blindness*: In the United States, vision of 20/200 in the better eye with best possible correction (AOA, 2006a).

*Age-related eye disease (ARED)*: The main causes of vision impairment and blindness in the U.S., which includes age-related macular degeneration, cataract, diabetic retinopathy and glaucoma (Prevent Blindness America, 2002).

*Age-related macular degeneration (AMD):* A degenerative disorder of the retina at the area of highest concentration of photoreceptors (macula), which leads to legal blindness (Snodderly, 1995).

*Age-related cataract:* The opacification and dysfunction of the lens of the eye from the accumulated effects of photooxidation and aging (Taylor, Jacques, & Epstein, 1995).

### *Limitations of the Study*

This study was limited by the optometrists who chose to respond to the survey and the design of the survey questions. The responses received may not accurately represent the practices and feelings of licensed Wisconsin optometrists overall. Data may be biased toward optometrists who feel strongly in favor of lutein supplements. While the Age-Related Eye Disease Study (AREDS), a major eye study in which optometrists are likely to base their nutritional recommendations, evaluated the effect of high-dose vitamins and minerals taken together on the progression of AMD and age-related cataract, the survey asked about these nutrients individually and did not separate recommendations for patients at different stages of AMD.

### *Methodology*

A 20-item survey was developed after review of the literature on lutein and zeaxanthin, antioxidants, AMD and cataract. The survey was pre-tested by three licensed optometrists. The survey was mailed to 300 randomly chosen licensed optometrists in Wisconsin in May 2003. Data were entered and analyzed using SPSS version 11.5 for Windows.

## Chapter II: Literature Review

### *Introduction*

This chapter will discuss lutein and zeaxanthin in age-related eye disease (ARED). The first section will describe the occurrence of visual impairment, blindness, age-related macular degeneration (AMD) and cataract. The next section will review the current observational and clinical research on lutein and zeaxanthin in AMD and cataract. The last section will examine lutein and zeaxanthin in foods or supplements and factors that may influence their digestion and safety.

### *Vision Impairment, Blindness and Age-Related Eye Disease*

An estimated 3.4 million Americans age 40 and older (2.9%) are visually impaired while more than one million of this group (0.9%) is considered legally blind (Prevent Blindness America, 2002). Women are affected more by vision impairment and blindness than men. Approximately 3.5% of women and 2.1% of men age 40 and older in the United States are visually impaired while 1.1% of women and 0.6% of men are blind. There is a higher incidence of vision impairment in the White race (3.1%) compared to the Black (2.2%), Hispanic (1.9%) or other races (1.8%). When the percent of the total cases of vision impairment due to blindness is compared by race, Blacks are the most affected by blindness (42.2%) and Hispanics are the least affected (13.6%). Vision impairment and blindness tends to increase considerably after age 75. The rate of vision impairment and blindness is expected to double in the next 30 years due to the aging Baby Boomer generation.

The above rates of vision impairment and blindness may appear small while blindness among races may appear high. To better understand these statistics, it should be noted that the reported rates of vision impairment include the total U.S. population age 40 and older who have

vision of 20/40 or worse in the better eye even after correction. Similarly, the reported rates of blindness include the total population age 40 and over who are legally blind. In contrast, the reported rates of blindness among races include only blind persons age 40 and older in the U.S. Therefore, the rates of vision impairment and blindness may seem low because of less vision impairment and blindness among the middle aged (age 40 to 70) while the rates of blindness may appear elevated among races because these are expressed as percentage of the total blind rather than percentage of the total race age 40 and older.

The four leading causes of vision impairment and blindness in the U.S. are AMD, cataract, diabetic retinopathy and glaucoma (Prevent Blindness America, 2002). These conditions are collectively referred to as ARED. This paper will concentrate on AMD and cataract. When speaking of cataract, age-related cataract is assumed. AMD is the main cause of blindness in persons age 60 and older in the United States while cataract is the primary cause of blindness in the world (NEI, 2002, March).

Blindness from AMD and cataract affects quality of life by restricting one's ability to read, write, drive a car and perform other activities of daily living. Brody et al. (2001) found 32.5% of participants with late AMD (20/60 vision) have depression, which was twice the rate of community-dwelling older adults. Vision loss also affects the national economy. It is expected that the federal government will lose four billion dollars annually in benefits and taxable income due to blindness and vision impairment (Prevent Blindness America, 2002).

#### *Age-Related Macular Degeneration (AMD)*

The two forms of AMD are dry AMD and wet AMD (Prevent Blindness America, 2002). The most common form, dry AMD, usually progresses slowly in the early stage (Gottlieb, 2002). Early dry AMD is characterized by fatty, yellow deposits called drusen (Prevent Blindness

America) within the macula that are large and numerous (Gottlieb). The macula is the central area of the retina with the highest concentration of light-receptor cells, which provides sharp central vision. Late stage dry AMD involves atrophy of the retinal pigment epithelium (geographic atrophy), which can cause loss of central vision. While only about 15% of AMD cases are the wet form (Gottlieb), all of these are considered late stage because of the severe vision loss due to the growth of new blood vessels (neovascularization) that leak and form scar tissue (Prevent Blindness America).

Approximately 1.6 million Americans age 50 and older (2.2%) have late AMD (Prevent Blindness America, 2002; "U.S. Census 2000"). Females (2.5%) are affected slightly more than males (1.7%). The incidence of late AMD in Wisconsin is estimated at 2.4% with 2.9% of females and 1.9% of males affected, which is slightly higher than the national rate. The Beaver Dam, Wisconsin population had a prevalence of late AMD of 1.6% among persons age 43 to 86 years (Klein, Klein, & Linton, 1992). Late AMD is most common in the White race (2.4%) followed by Blacks (1.4%), Hispanics (1.2%) and other races (1.2%). The Eye Diseases Prevalence Research Group (EDPRG, 2004a) found AMD to be the leading cause of blindness in White Americans.

The rates of AMD are better understood when data are summarized by age, gender, and race (See Table 1). According to The Eye Diseases Prevalence Research Group (2004b) data, females have a higher rate of advanced AMD than males of the same race. Although black females have a higher rate in the earlier years (ages 50 to 69), white females have a higher rate in the later years (ages 70 to  $\geq 80$ ). This is due to a sharp increase among white females beginning at age 70 compared to black females who have a more moderate increase with age. Similarly,

white males show a pattern of sharp increase of advanced AMD beginning at age 70 in contrast to black males who continue with a gradual increase with age.

Table 1  
Prevalence of advanced age-related macular degeneration  
(AMD) by age, gender and race

Gender/Age, years	Rate per 100 individuals (95% CI)	
	White Race	Black Race
<b>Females</b>		
50-54	0.20 (0.17-0.24)	0.68 (0.57-0.80)
55-59	0.22 (0.20-0.24)	0.82 (0.71-0.96)
60-64	0.35 (0.33-0.39)	1.00 (0.86-1.15)
65-69	0.70 (0.64-0.76)	1.21 (1.04-1.42)
70-74	1.52 (1.41-1.64)	1.47 (1.23-1.76)
75-79	3.44 (3.22-3.69)	1.79 (1.45-2.21)
≥ 80	16.39 (14.97-17.91)	2.44 (1.85-3.20)
<b>Males</b>		
50-54	0.34 (0.23-0.50)	0.42 (0.25-0.70)
55-59	0.41 (0.34-0.50)	0.52 (0.33-0.80)
60-64	0.63 (0.53-0.75)	0.63 (0.42-0.95)
65-69	1.08 (0.91-1.29)	0.77 (0.50-1.18)
70-74	1.98 (1.69-2.32)	0.93 (0.57-1.53)
75-79	3.97 (3.18-4.24)	1.14 (0.63-2.05)
≥ 80	11.90 (9.78-14.41)	1.56 (0.72-3.35)

*Note.* Adapted from EDPRG, 2004b.

The primary cause of AMD is still unknown (Prevent Blindness America, 2002) but risk factors include old age, female sex, white race, cigarette smoking, and low dietary intake of carotenoids (Gottlieb, 2002). Currently, there is no treatment to prevent or cure AMD but laser therapy has been shown to delay vision loss in some patients at risk for wet AMD.

#### *Age-Related Cataract (Cataract)*

The lens of the eye is naturally clear but aging, exposure to sunlight, cigarette smoking, diet or alcohol consumption may lead to the clouding of the lens called age-related cataract (Prevent Blindness America, 2002). Cataracts can be classified by type, extent, and density including cortical, posterior sub-capsular, and nuclear (West, 1991). Unlike AMD, a widely accepted treatment has been found for cataract, which involves removal of the natural lens of the

eye and replacement with an artificial implant (Prevent Blindness America). Medicare spends an estimated 3.4 billion dollars a year in treating cataract. Cataract extraction is the most common surgical procedure in the U.S. with more than two million procedures per year (“Nutrition & Cataracts,” n.d.). Although cataract surgery has become quite common, cataract still remains a primary cause of vision impairment and blindness in those with barriers to accessing appropriate eye care, especially those in developing countries (West).

Cataract affects about 20.5 million Americans age 40 and older (17.2%) (Prevent Blindness America, 2002). Prevalence is higher in females (20.0%) than males (13.9%). The incidence of cataract in Wisconsin is estimated to be 17.9% with 20.9% of females and 14.6% of males affected. Whites have the highest rate of cataract (18.5%) with Blacks (12.9%), other races (12.4%), and Hispanics (11.7%) following closely behind. Cataract is the main cause of low vision (excluding blindness) in Whites (59.2%), Blacks (50.9%), and Hispanics (46.7%) (EDPRG, 2004a). Cataract (36.8%) was the most common cause of blindness in Black Americans according to the EDPRG (2004a).

As with AMD, the rates of cataract are better understood when data are summarized by age, gender, and race (See Table 2). In like manner, females have a higher rate of cataract compared with males of their race. Again, black females have a higher rate of cataract in the earlier years (age 40 to 69) while white females have a higher rate in the later years (age 70 to  $\geq$  80). In contrast, compared to the sharp increase in advanced AMD with age among whites, the increase is gradual among both races and genders for cataract.

Table 2  
Prevalence of cataract by age, gender and race

Gender/Age, years	Rate per 100 individuals (95% CI)	
	White Race	Black Race
Females		
40-49	1.9 (1.2-2.8)	2.2 (1.4-3.5)
50-54	5.0 (4.0-6.2)	7.3 (5.7-9.3)
55-59	9.4 (7.7-11.5)	12.8 (10.2-16.0)
60-64	16.9 (14.1-20.0)	20.1 (16.4-24.2)
65-69	27.7 (24.1-31.6)	28.5 (24.3-33.1)
70-74	41.0 (36.9-45.1)	37.4 (32.6-42.5)
75-79	54.7 (50.2-59.1)	46.1 (40.1-52.2)
≥ 80	76.6 (71.2-81.2)	60.9 (51.0-69.9)
Males		
40-49	2.8 (2.1-3.7)	1.7 (1.1-2.5)
50-54	4.9 (4.2-5.7)	4.5 (3.6-5.6)
55-59	8.2 (7.0-9.5)	4.6 (6.2-9.3)
60-64	13.8 (12.1-15.7)	11.9 (9.9-14.2)
65-69	22.4 (20.1-24.8)	17.5 (15.0-20.3)
70-74	33.9 (31.2-36.8)	24.1 (21.0-27.5)
75-79	47.2 (43.9-50.4)	31.3 (27.1-36.0)
≥ 80	71.3 (67.0-75.2)	46.2 (37.9-54.6)

*Note.* Adapted from EDPRG, 2004c.

In summary, the incidence of AMD and cataract is expected to rise with higher rates among the Wisconsin population compared to the total U.S. Blindness from AMD and cataract can affect an individual's physical, social and psychological functioning as described above. Interestingly, an estimated 50% of all cases of blindness may be preventable (Prevent Blindness America, 2002). Dietary antioxidants are one possible route of prevention which will be discussed in the next section. Specifically, the role of lutein and zeaxanthin but also other carotenoids, vitamins A, C, and E, and zinc in the protection against ARED will be included.

#### *Dietary Intake, Serum Concentrations and Age-related Eye Disease*

The Eye Disease Case-Control Study (Seddon, Ajani, et al., 1994) evaluated the relationship between dietary intake of carotenoids and vitamins A, C, and E and the risk of late AMD in patients aged 55 to 80 years from five ophthalmology centers in the U.S. Total

carotenoids, total vitamin A, beta-carotene, and lutein and zeaxanthin showed a significant trend of decreased risk with increasing intake. Lutein and zeaxanthin had the strongest association of the carotenoids and overall with a statistically significant trend ( $P < .001$ ) for a reduced risk of late AMD. Spinach and collard greens were the only carotenoid-rich foods to show a significant inverse trend with late AMD. An 86% lower risk was found for those who ate five or more servings of spinach or collard greens (one serving equals 0.5 cups, cooked or raw) per week compared to those who ate less than one serving per month (OR: 0.14; 95% CI: 0.01, 1.2;  $P$  for trend =  $< .001$ ).

Two prospective studies compared carotenoid and vitamin A intake with the risk of cataract extraction in men and women. The intake of U.S. male health professionals aged 45 to 75 years from the Health Professionals Follow-Up Study (Brown et al., 1999) and registered female nurses aged 45 to 71 years from the Nurses' Health Study (Chasan-Taber et al., 1999) were evaluated with a semi-quantitative food-frequency questionnaire. In the men, only lutein and zeaxanthin had a significant trend ( $P = .03$ ) for decreased risk with increasing intake (Brown et al.). Men in the highest quintile of lutein and zeaxanthin intake (6.9 mg) had a 19% lower risk of cataract extraction compared to men in the lowest quintile (1.3 mg) (RR: 0.81; 95% CI: 0.65, 1.01;  $P$  for trend =  $.03$ ). In the women, both lutein and zeaxanthin and vitamin A without supplements showed a significant trend ( $P = .04$ ) for decreased risk with increasing intake although only women at the top decile of lutein and zeaxanthin intake (13.7 mg) had a significantly decreased risk compared to the bottom quintile (1.2 mg) (RR: 0.78; 95% CI: 0.63, 0.95;  $P$  for trend =  $.04$ ) (Chasan-Taber et al.). Frequent intake ( $\geq 2$  times per week) of cooked spinach was most strongly associated with lower risk with 38% lower risk than those with intake less than 1 time per month (RR: 0.62; 95% CI: 0.45, 0.86;  $P$  for trend =  $.005$ ).

Dietary intake and serum concentrations and AMD have been examined using data from the National Health and Nutrition Examination Survey (NHANES). Goldberg, Flowerdew, Smith, Brody, and Tso (1988) compared the consumption of vitamins A and C and the prevalence of AMD among persons aged 45 to 74 years from the NHANES I. Consumption data was collected through a 24-hour recall and food frequency questionnaire of fruits and vegetables rich in vitamins A and C reported as weekly intake over the previous three months. Intake of fruits and vegetables rich in vitamin A (OR: 0.57; 95% CI: 0.34, 0.96) and rich in vitamin C (OR: 0.48; 95% CI: 0.27, 0.87) four to six times per week from the food frequency data showed significance for a decreased risk of AMD. After adjustment for demographic and medical factors, only intake of fruits and vegetables rich in vitamin A seven or more times per week remained significant (OR: 0.59; 95% CI: 0.37, 0.99).

Mares-Perlman et al. (2001) compared the relationship between lutein and zeaxanthin in the diet and serum and photographic evidence of early and late AMD in persons aged 40 years and older from the NHANES III. Intake data was obtained from a 60-item food frequency questionnaire. A significantly reduced risk of pigmentary abnormalities (early AMD) was found in persons aged 40 to 59 years from all races combined (OR: 0.1; 95% CI: 0.1, 0.3) and Non-Hispanic Whites (OR: 0.3; 95% CI: 0.1, 0.3) in those with the highest versus the lowest quintile of lutein and zeaxanthin intake in the diet. A significant reduction in late AMD was found in persons aged 60 to 79 years from all races combined in those with the highest versus the lowest quintile of lutein and zeaxanthin intake in the diet (OR: 0.1; 95% CI: 0.0, 0.9). The 90th percentile for lutein and zeaxanthin intake was 5.6 mg in persons aged 40 to 59 years and 6.0 mg in persons aged 60 to 79 years.

The relationship between serum carotenoids and tocopherols and AMD or cataract was compared using data from the Beaver Dam Eye Study, a case-control study within a population-based cohort. Mares-Perlman et al. (1995) investigated the relationship between serum levels and AMD. No significant differences were found between mean levels of all carotenoids and tocopherols in persons with or without AMD. While a significantly lower mean level of alpha-tocopherol was found in persons with AMD than in persons without AMD ( $P = .03$ ), the difference was no longer significant after adjusting for serum cholesterol levels. No significant differences were observed between the highest and lowest quintile of serum carotenoids and tocopherols and AMD. A significantly increased risk was shown in persons in the lowest quintile of serum lycopene versus all other quintiles combined before (OR: 1.9; 95% CI: 1.0, 3.7) and after adjustment (OR: 2.2; 95% CI: 1.1, 4.5). Lyle et al. (1999) investigated the relationship between serum levels and cataract. There was a significant trend of decreased risk of cataract with increasing levels of serum tocopherol. Persons in the highest versus the lowest tertile of serum tocopherols showed a significantly reduced risk for cataract (OR: 0.4; 95% CI: 0.2, 0.9;  $P = .03$  for trend).

#### *Antioxidant Supplements and Intake and Age-Related Cataract*

The effect of antioxidant supplements on the prevention of age-related cataract has been studied. Robertson, Donner, and Trevithick (1991) obtained the self-reported intake of vitamin supplements from the interviews of 304 persons (152 case-control pairs: 59 male, 93 female) living in southwestern Ontario. The majority (90%) of these participants were aged 60 years or older. Supplementary vitamin C (OR: 0.30; 95% CI: 0.12, 0.75;  $P = .01$ ) and E (OR: 0.44; 95% CI: 0.24, 0.77;  $P = .004$ ) intake among participants without cataract was significantly higher than

that of the participants with cataract. These results suggest that supplementary vitamins C and E may reduce the risk of cataract by 70% and 56%, respectively.

Jacques et al. (1997) invited cataract-free women with the highest and lowest intakes of vitamin C from the Nurses' Health Study to participate in an investigation of supplement use over 10 to 12 years before assessment for lens opacities. There were 247 participants aged 56 to 71 years (mean age at eye exam of 62.6 years). Most of the opacities found were early nuclear (61.1%). Women who took vitamin C supplements for 10 years or longer had a significantly lower risk of both early (OR: 0.23; 95% CI: 0.09, 0.60) and moderate (OR: 0.17; 95% CI: 0.03, 0.87) opacities at any lens location. No evidence was found for reduced risk from vitamin C supplement intake for less than 10 years.

Taylor et al. (2002) assessed the total nutrient intake from both food and supplements among women of the Nurses' Health Study and compared it with age-related cortical and posterior subcapsular (PSC) opacities from subsequent eye exams. Data were collected from questionnaires of 492 women aged 53 to 73 years over 13 to 15 years before eye assessment. Although no significant trends were found between any of the nutrients and either type of opacities in the overall cohort, a significant association was shown between age and total vitamin C intake and age and years of vitamin C intake for cortical opacities. A significant inverse trend was found only among those aged less than 60 years ( $P$  for trend .02) for cortical opacities with increasing vitamin C intake. Those in the highest quintile of vitamin C intake (OR: 0.43; 95% CI: 0.20, 0.93) (364 mg to 2342 mg) had a 57% decreased risk for cortical lens opacities compared to those in the lowest quintile (140 mg or less). Similarly, a significant inverse trend was found only among those aged less than 60 years ( $P$  for trend .008) for cortical opacities with increasing duration of vitamin C supplement use. Those who took vitamin C supplements for 10

years or longer (OR: 0.40; 95% CI: 0.18, 0.87) had a 60% decreased risk for cortical lens opacities compared to those who did not use vitamin C supplements.

The use of vitamin supplements and risk for cataract has been studied among males. Seddon, Christen, et al. (1994) examined the self-reported intakes of multivitamin, vitamin C, and/or vitamin E supplements in 17,744 cataract-free males aged 40 to 84 years from the Physicians' Health Study (PHS). Cataract was assessed by report of the participant in a follow-up questionnaire and documentation by ophthalmologist in the medical record. The authors did not find any significant association between use of vitamins C or E and reduced risk of cataract although these numbers were too small to evaluate. A marginally significant decreased risk of cataract was found among men who took only a multivitamin supplement (RR: 0.73; 95% CI: 0.54, 0.99;  $P = .04$ ) compared to men who did not take any vitamin supplements. In addition, a trend that approached significance ( $P$  for trend .06) was found for decreased risk of cataract with increasing duration of multivitamin use.

### *Macular Pigment Density*

The macula lutea (macula), or yellow spot, of the retina contains the carotenoids lutein and zeaxanthin (Pratt, 1999). The central-most part of the macula, or the fovea, has the highest concentration of these yellow pigments (Snodderly, 1995). They are referred to as the macular pigment (Pratt). Two possible roles of the macular pigment have been suggested: filtering of damaging blue light from the sun and protection from oxidative damage to lipid membranes of the eye (Pratt). Low macular pigment density (MPD) may be a risk factor for AMD, cataract and age-related vision loss. Understanding the factors that influence MPD may assist in the prevention and treatment of these age-related eye diseases.

MPD and visual sensitivity were assessed and compared between a group of younger participants (aged 24 to 36 years) and older participants (aged 60 to 84 years) who were non-smokers and had good ocular health (Hammond, Wooten, & Snodderly, 1998). The older age group showed a significant positive relationship between MPD and all three measures of visual sensitivity although no significant relationships were found in the younger subjects. When the age groups were combined and divided according to their MPD, the group with low MPD had significantly lower visual sensitivity (in one measure) than those with high MPD. A significant decrease in MPD was found only in persons older than 60 years. These results suggest that MPD may prevent age-related loss of visual function.

Studies have investigated the association of serum concentrations, adipose tissue concentrations, and dietary intake with MPD. A Netherlands study (Broekmans et al., 2002) compared the association between serum lutein and zeaxanthin concentrations and adipose lutein concentrations on MPD in volunteers aged 18 to 75 years. This study found gender-related differences, which may explain the higher occurrence of AMD among women. Although serum lutein and zeaxanthin concentrations ( $P < .05$ ) and adipose lutein concentrations ( $P < .001$ ) were significantly lower in men than in women, mean MPD was 13% higher in men than in women ( $P = .02$ ). An Indianapolis area study (Curran-Celentano et al., 2001) evaluated the serum concentrations, dietary intake, and MPD in volunteers between ages 18 and 50 years. Dietary intake was assessed using a one-year food frequency questionnaire. The study found a significant negative relationship between number of cigarettes smoked per day for current smokers and total serum carotenoids ( $r = -.32, P < .005$ ) and serum lutein and zeaxanthin ( $r = -.26, P < .025$ ). A significant positive relationship was found between serum lutein ( $r = .26, P < .0001$ ), serum

zeaxanthin ( $r = .20$ ,  $P < .0001$ ), and dietary intake of lutein and zeaxanthin ( $r = .21$ ,  $P < .0005$ ) and MPD.

The relationship of anthropometric measurements to MPD has been investigated (Hammond, Ciulla, & Snodderly, 2002). Researchers tested the relationship between percent body fat and body mass index (BMI) and MPD in participants from Athens, Georgia and Indianapolis (mean age 29.6 years). The average BMI of participants from Athens and Indianapolis was 24 and 26, respectively. Percent body fat was assessed by bioelectric impedance and dietary intake was measured using a food frequency questionnaire. A significant inverse relationship was found between both BMI ( $r = -.12$ ,  $P < .0008$ ) and percent body fat ( $r = -.12$ ,  $P < .01$ ) and MPD although this relationship was influenced by participants with a high BMI and percent body fat. No relationship was found when these participants were removed. Mean MPD was significantly lower in participants with a BMI greater than 29 than those with a BMI less than 29. Similarly, mean MPD was significantly lower in participants with greater than 27% body fat than those less than 27% body fat. In addition, dietary intake of lutein and zeaxanthin and total serum carotenoids were significantly lower in high BMI participants ( $>29$ ). The authors hypothesized that these differences in MPD may be due to diet and competition with adipose tissue for lutein and zeaxanthin uptake.

Scientists have attempted to manipulate macular pigment and tissue concentrations through diet. Hammond, Johnson, et al. (1997) tried to increase MPD through dietary intake of food sources of lutein and zeaxanthin. Thirteen non-smokers aged 30 to 65 years ate 60 grams of spinach and 150 grams of corn per day ( $n = 10$ ), or ate only the spinach ( $n = 1$ ) or the corn ( $n = 2$ ), with a meal and/or fat source in addition to their usual dietary intake for 15 weeks. Those who responded to the spinach and corn or spinach only ( $n = 8$ ) had significant increases in MPD

from baseline at weeks 4, 12, and 14 but had a temporary return to baseline at week 8. This is suggested to reflect interaction with other tissues (i.e. adipose). The responses to corn only differed with one person showing a considerable increase in serum zeaxanthin (70%) and MPD (25%) while the other person showed mild increases (6%, 7%) in these measurements, respectively. Johnson et al. (2000) followed the same dietary protocol of spinach and corn for 15 weeks but also compared the relationships between anthropometric measurements, MPD, and serum, tissue, and dietary lutein concentrations. Similar to the results of Hammond, Johnson, et al. (1997), this study found a significant increase in MPD except at week 8. Interestingly, when MPD decreased at week 8, adipose tissue concentrations increased significantly. These studies show a possible competition between the adipose and macular tissue for serum carotenoids.

Scientists have investigated the influence of lutein supplementation on MPD. Landrum et al. (1997) provided 30 mg of free lutein per day to two healthy male volunteers (aged 42 and 51) for 140 days. The supplement, which was taken after breakfast, was natural lutein esters extracted from marigolds and suspended in 2 ml oil. An increase in MPD started at approximately days 20 to 40 and continued to increase 40 to 50 days after supplementation ended. Serum concentrations increased tenfold after 10 to 20 days of supplementation then dropped to baseline at about 60 days of discontinuing the supplement. The supplementation produced a 39% and 21% mean increase in MPD in the two volunteers, respectively. Similarly, Berendschot et al. (2000) found a daily lutein supplement significantly increased MPD in eight nonsmoking volunteers albeit for a shorter length of time (12 weeks) and with a lower dose (10 g). Landrum et al. showed little or no decrease in MPD after the serum concentrations returned to baseline, which may indicate a slow turnover rate in the retina. The authors suggest that MPD may reflect carotenoid consumption over an extended length of time. Consistent with this

thought, Hammond, Johnson, et al. (1997) found MPD to remain elevated for several months after ending a modified diet.

#### *Aging, Antioxidant Concentrations and Age-Related Cataract*

The lens is located behind the cornea and iris of the eye and is in contact with the aqueous humor (Taylor et al., 1995). The youngest tissue is composed of a unicellular layer of epithelial cells on the anterior surface. These cells divide, differentiate and are compressed posteriorly into the cortex. The oldest tissue is located in the nucleus of the lens (Yeum, Shang, Schalch, Russell, & Taylor, 1999). These three layers are surrounded by an outer collagenous membrane called the capsule (Taylor et al., 1995). The main role of the lens is to collect and focus light onto the retina. Cataract results when damage due to dehydration and photooxidation of the lens proteins causes opacification.

The ocular lens is about 98% protein (Taylor et al., 1995). Since these lens cells are typically not lost with aging, they are at particular risk of harm from light and oxygen. This may come in the form of ultraviolet light and smoking as well as low concentrations of antioxidant nutrients. The lens protects itself from damage through antioxidant nutrients, antioxidant enzymes, and proteolytic enzymes. It has been proposed that cataract results from the imbalance of these protective systems as discussed elsewhere.

Researchers have measured the concentration of antioxidant nutrients in the eye. Yeum, Taylor, Tang, and Russell (1995) compared the carotenoid, retinoid, and tocopherol concentrations of normal and cataractous American and cataractous Indian lenses. Lutein and zeaxanthin were the only carotenoids while retinol, retinyl palmitate, alpha-tocopherol, and gamma-tocopherol were also found in the human lenses. No differences were found between the normal and cataractous American lenses. Interestingly, concentrations of lutein, zeaxanthin, and

retinol were significantly higher in the Indian cataractous lenses than both the cataractous and normal Americans lenses. The authors suggest that other factors also determine cataract risk.

Risk of a type of cataract may be related to the antioxidant concentrations in the layers of the lens. Yeum et al. (1999) compared the carotenoids, retinol, and tocopherol in the epithelium/cortex with those in the nucleus. The epithelium/cortex was found to have 3, 1.3, and 1.8 times more lutein and zeaxanthin, retinol, and tocopherol, respectively. Of the total lens, 75% of lutein and zeaxanthin, 60% of retinol, and 64% of tocopherol were found in the epithelium/cortex. Even though less exposure to irradiation and oxygen occur in the nucleus, there is a greater occurrence of this type of cataract. Yeum et al. (1999) have proposed that greater amounts of these antioxidants in the outer layers of the lens may explain the lower incidence of these types of cataract.

Increased lens optical density (LOD) is an indicator of an aging lens with cataract being the end stage. Studies have shown a significant increase in LOD with age (Hammond, Wooten, & Snodderly, 1997; Berendschot et al., 2002). Hammond, Wooten, et al. (1997) compared the association between MPD and LOD in younger (aged 24 to 36 years) and older (aged 48 to 82 years) subjects. A significant inverse relationship was found only in the older group ( $r = -.47$ ,  $P < .001$ ). Berendschot et al. (2002) confirmed these results ( $\beta = -.240$ ,  $P = .005$ ). These studies give support to lutein and zeaxanthin in the protection from age-related increases in LOD and cataract (Hammond, Wooten, et al., 1997; Berendschot et al., 2002). Since lutein and zeaxanthin can not be measured in the lens *in vivo*, MPD as a biomarker of lens health has shown to be effective.

### *Major Clinical Trials*

The Age-Related Eye Disease Study (AREDS) was a double-blind, randomized, placebo-controlled clinical trial of 4600 participants in one of four categories of AMD selected from 11 U.S. clinical centers (AREDS Group, 2001a). The AREDS evaluated the effect of high-dose vitamin C (500 mg), vitamin E (400 IU), beta-carotene (15 mg), zinc (80 mg) and copper (2 mg) supplements on AMD progression and visual acuity. Participants were randomly assigned to take daily tablets with: (1) antioxidants, (2) zinc and copper, (3) antioxidants plus zinc or (4) a placebo. Those not at risk for AMD received only the antioxidants to evaluate the risk of age-related cataract and visual acuity loss (AREDS Group, 2001b). Zinc (OR: 0.71; 99% CI: 0.52, 0.99) and antioxidants plus zinc (OR: 0.66; 99% CI: 0.47, 0.91) significantly reduced the risk of progression to advanced AMD in persons with intermediate and advanced AMD. But only those who received antioxidants plus zinc showed a statistically significant reduction in the rate of at least moderate visual acuity loss (OR: 0.73; 99% CI: 0.54, 0.99). Alternatively, no effect of treatment on the development or progression of age-related cataract or visual acuity loss was found. The AREDS was the first National Institutes of Health funded study to determine the effect of high-dose dietary supplements on AMD. Notably, since commercial lutein supplements were not available at the start of the AREDS, this could not be evaluated (NEI, 2002, July).

The Lutein Antioxidant Supplementation Trial (LAST) was a double-blind, randomized, placebo-controlled clinical trial of 90 patients with atrophic AMD at two Chicago area veterans medical facilities (Richer et al., 2004). The aim of the study was to evaluate the effect of lutein alone or lutein with carotenoids, antioxidants, vitamins and minerals on MPD and measures of central vision in persons with the most common form of AMD. In comparison, the LAST was shorter (1 year versus 7 years), had an older mean age (75 years versus 69 years), and had more

male volunteers (95% versus 44%) than the AREDS (Richer et al.; AREDS Group, 2001a). Patients in the LAST were given: (Group 1) 10 mg lutein, (Group 2) 10 mg lutein combined with antioxidants, vitamins, and minerals (OcuPower® from Nutraceutical Sciences Institute), or (Group 3) maltodextrin (Richer et al.). Contents of the OcuPower® supplement given to Group 2 are shown in Table 3. Visual function was assessed using several measures as described elsewhere. Of these measures, there was an objective improvement in MPD, Snellen visual acuity, and contrast sensitivity for Groups 1 and 2 while a subjective improvement in the Amsler grid for Group 1 and glare recovery in Group 2 was found. This is the first trial to show improvement of several visual functions in patients with AMD (North Chicago VA Medical Center, 2004). This study supports the effectiveness of lutein combined with antioxidants, vitamins and minerals in the treatment of AMD although further studies are needed to confirm this result. In addition, lutein supplementation was found to benefit all stages of AMD (Richer et al.) as opposed to the AREDS, in which high-dose vitamins and minerals were found to benefit only moderate to severe stages of AMD (AREDS Group, 2001a).

Table 3  
 Contents of the OcuPower® supplement taken during the LAST study

Ingredient	Dose	% RDA/AI <sup>a</sup>
Lutein (FloraGlo®)	10 mg	--
Vitamin A	2500 IU	83-108%
Beta-carotene (Betatene®)	15000 IU	--
Vitamin C (calcium ascorbate-Ester C®)	1500 mg	1667-2000%
Vitamin D3	400 IU	67-200%
Vitamin E (d-alpha tocopherol succinate)	500 IU	2222%
Vitamin B1 (thiamin)	50 mg	4167-4545%
Vitamin B2 (riboflavin)	10 mg	769-909%
Vitamin B3 (niacin)	70 mg	438-500%
Vitamin B5 (pantothenic acid)	50 mg	1000%
Vitamin B6	50 mg	2941-3846%
Vitamin B12	500 mcg	20833%
Folic acid	800 mcg	200%
Biotin	300 mcg	1000%
Calcium	500 mg	42%
Magnesium	300 mg	71-94%
Iodine	75 mcg	50%
Zinc (L-methionine—L-OptiZinc®)	25 mg	227-313%
Copper	1 mg	10%
Manganese	2 mg	87-111%
Selenium	200 mcg	36%
Chromium	200 mcg	667-1000%
Molybdenum	75 mcg	167%
Lycopene	600 mcg	--
Bilberry extract (25% anthocyanosides)	160 mg	--
Alpha lipoic acid	150 mg	--
N-acetyl cysteine	200 mg	--
Quercetin	100 mg	--
Rutin	100 mg	--
Citrus bioflavonoids	250 mg	--
Plant enzymes	50 mg	--
Black pepper extract (Bioperine®)	5 mg	--
Malic acid	325 mg	--
Taurine	900 mg	--
L-glycine	100 mg	--
L-glutathione	10 mg	--
Boron	2 mg	--

*Note.* See Richer et al., 2004. -- = No RDA/AI

<sup>a</sup>Percent Recommended Daily Allowance/Adequate Intake for females and males aged 50 years and over.

*Lutein and Zeaxanthin: Sources, Bioavailability and Metabolism*

Lutein and zeaxanthin can be obtained through foods or supplements. Dark green leafy vegetables such as kale, collard greens or spinach are the highest dietary sources of lutein and zeaxanthin while moderate amounts are found in green or yellow vegetables including squash, peas, broccoli, Brussels sprouts and corn (USDA, n.d.). Lutein first became available to the supplement market in 1995 in the form of purified, crystalline lutein and zeaxanthin from marigold flowers (Kreuzer, n.d.). It is now found in hundreds of nutritional supplements (Lutein Information Bureau, 2006).

Scientists have studied the bioavailability and metabolism of carotenoids from foods and supplements. Castenmiller, West, Linssen, Hof, and Voragen (1999) studied the affect of different levels of processed spinach on the availability of  $\beta$ -carotene and lutein. The study included a control, carotenoid supplement, whole leaf spinach, minced spinach, liquefied spinach and liquefied spinach plus dietary fiber group. All groups were fed the same 1-week cycle diet over a 3-week period. The authors found that processing spinach did not affect the bioavailability of lutein. The relative bioavailability of lutein was found to be 52% from minced spinach (Castenmiller et al.) and 67% from a high-vegetable diet (Hof et al., 1999) of the bioavailability of a lutein supplement added to salad dressing. This shows a lutein supplement is better absorbed by the body than vegetable-borne lutein.

Lutein may compete with other carotenoids for absorption. Tyssandier et al. (2002) found competition in chylomicron response to vegetable-borne lutein and lycopene but no effect on plasma concentration after 3-week supplementation periods. There was a significant increase in plasma lutein concentrations after 3-week supplementation with chopped spinach, chopped spinach plus tomato puree, chopped spinach plus lycopene, and lutein plus tomato puree. Burri,

Neidlinger, and Clifford (2001) compared the half-lives of common carotenoids in healthy women fed a low-carotenoid diet. Lutein was found to have the longest half-life at 76 days while zeaxanthin had a half-life of 38 days.

#### *Dietary Recommendations and Intake*

National organizations have set recommended intakes for fruits and vegetables. One of the Healthy People 2010 objectives is to eat at least three servings of vegetables daily with at least one-third being dark green or orange (FDA & NIH, 2000). Only 3% of the population met this recommendation in 1994-1996. The Dietary Guidelines for Americans recommends eating a variety of fruits and vegetables daily and to chose from all five vegetable subgroups, including dark green, several times weekly (USDHHS, 2005). The national 5 A Day for Better Health Program was started in 1991 as a partnership between the vegetable and fruit industry and the U.S. government with the goal to increase intake of vegetables and fruits to 5 servings per day and decrease the incidence of chronic diseases (NCI, 2001).

Currently, no recommended level of lutein and zeaxanthin intake has been proposed (The National Academy of Sciences, 2000) although the Eye Disease Case Control Study and analysis of the Third National Health and Nutrition Examination Survey found 5.8 mg (Seddon, Ajani, et al., 1994) and 6 mg (Mares-Perlman et al., 2001) per day, respectively reduced the risk of AMD. Analysis of the Nurses' Health Study and Health Professionals Follow-Up Study showed 6 mg (Chasan-Taber et al., 1999) and 6.9 mg (Brown et al., 1999) per day, respectively reduced the need for cataract surgery. The LAST study demonstrated 10 mg lutein per day improved visual function in persons with atrophic AMD (Richer et al., 2004).

Although several studies have shown a relationship between diets high in lutein and zeaxanthin and eye health, consumption remains low (CDC, 2006). The Behavioral Risk Factor

Surveillance System telephone health survey found that in 2005, only 23.2% of adults nationwide and 22.2% of adults in Wisconsin consumed fruits and vegetables five or more times per day. The 50th percentile for lutein and zeaxanthin intake varies according to study population. The Beaver Dam Eye Study showed a 0.9 mg per day intake (Mares-Perlman et al., 1995) while the Eye Disease Case Control Study found a 1.7 mg per day intake (Seddon, Ajani, et al., 1994).

### *Safety and Use of Dietary Supplements*

The safety of taking lutein and other nutritional supplements for age-related cataract and macular degeneration has been questioned (Sperduto, Ferris, & Kurinij, 1990; Mares-Perlman, 1999). In 1990, Sperduto et al. advised caution in the recommendation of supplements for age-related macular degeneration and cataract due to unknown efficacy and undefined toxicity levels for many nutrients. In 1999, Mares-Perlman warned that enthusiastically recommending lutein supplements for cataract before a strong body of scientific evidence is established would damage the credibility of science in the public eye and may cause adverse outcomes as was the case with  $\beta$ -carotene and lung cancer. The National Eye Institute (NEI) released a statement in July 2002 explaining that claims supporting the role of lutein supplements in decreasing the risk of AMD or cataract were still speculative. Richer, the LAST lead investigator, makes clear in a North Chicago VA Medical Center (2004) statement that studies are needed of increased population and length of time on the treatment of AMD with lutein and antioxidant supplements. On the other hand, a recent study conducted by The Lewin Group (2006) for the Dietary Supplement Education Alliance estimated a five-year \$2.5 million net savings through avoiding dependency associated with risk of AMD by taking 6-10 mg of lutein with zeaxanthin daily. Clearly,

researchers differ in their perceptions of the appropriateness of lutein, zeaxanthin, and antioxidants for eye health.

Despite the lack of evidence regarding the long-term safety and efficacy of lutein in the prevention and treatment of AMD and cataract, it has become the most used herbal and other natural dietary supplement (Kelly et al., 2005). The main source of lutein supplementation was from a multivitamin product. The National Marketing Institute's survey (November 20, 2003) found 61.2% of Americans were aware of lutein, 29.2% said it was important for their stores to carry foods and beverages enriched with lutein, and 77.1% said they were concerned with preventing vision problems (as cited in Kemin Industries, Inc., 2006). The results of these surveys show the need for optometrists and other eye healthcare professionals to stay informed of the research on lutein and eye health and to provide credible recommendations and educational materials that consider the current body of evidence.

#### *Optometry and Nutrition Education*

Optometrists are uniquely positioned to promote the intake of a healthy diet including dark green vegetables for optimal eye health. They may also provide credible information to guide patients on the use of nutritional supplements. The American Optometric Association's Clinical Practice Guidelines advises optometrists that evidence is increasing to support nutritional supplementation for eye health but that further research is needed to define those therapies (AOA, 1999). Eating five or more servings of dark green leafy vegetables per week is suggested to reduce risk for AMD. Dietary supplementation with vitamins C and E, beta-carotene and selenium is recommended for nutrient-deficient or noncompliant adults although optometrists are advised to consult with the patient's primary care physician before recommending nutritional supplements. Referring a patient to a registered dietitian may assist

concerned optometrists in determining current dietary intake, the appropriateness of nutritional supplementation, or nutrition education for eye health.

## Chapter III: Methodology

### *Introduction*

The purpose of this study was to describe how the confidence of licensed Wisconsin optometrists in the relationship between diets high in lutein and zeaxanthin and eye health influenced their clinical practice as measured by a self-administered survey. This chapter will review subject selection and description, instrumentation, data collection, data analysis and limitations.

### *Subject Selection and Description*

A complete listing of 794 licensed Wisconsin optometrists was obtained from the Wisconsin Department of Regulations and Licensing. After assigning a three digit number to all optometrists excluding those who pre-tested the survey, a random sample of 300 optometrists was selected using a table of random digits. A letter of consent was mailed to the sample of optometrists requesting their participation in the study (Appendix A). The letter specified the objectives of the study, the subjects' rights as study participants, and that returning the survey indicated their agreement to participate. Since the study instrument was designed for currently practicing optometrists, the letter asked that only currently practicing optometrists participate. A pre-addressed, pre-paid envelope was included for return of the survey instrument. The surveys were not coded or marked with an identification number, and did not have any personal identifiers therefore the sample was anonymous.

### *Instrumentation*

A 20-item original survey was developed after a thorough review of epidemiological, prospective, and clinical studies on lutein and zeaxanthin found in nutrition, eye, and medical journals. Two locally practicing optometrists and one other practicing optometrist agreed to pre-

test the survey for errors and to improve the quality. Modifications in survey length and content were made based upon the pre-test. A copy of the survey is located in Appendix B. Since the role of lutein and zeaxanthin in eye health is still under investigation, it was the aim of this study to gather the opinions and recommendations of the most frequently sought providers of eye care, optometrists. The items in the survey were divided into four main sections.

The first section addressed Wisconsin optometrists' awareness of lutein and zeaxanthin, sources of information on lutein and zeaxanthin, and perception of the adequacy of the information on lutein and zeaxanthin. The first item was a 5-point scale measuring the awareness of optometrists on the relationship between lutein and zeaxanthin and eye health. The next two items were concerning the sources of information on the relationship between lutein and zeaxanthin and eye health. The first of the two items asked respondents to mark all of their sources of information while the second asked respondents to rank their top three most preferred sources of information. The last item in this section asked whether the information on lutein and zeaxanthin was adequate to make recommendations to patients.

The second section asked respondents to mark which of the following foods or supplements they recommended to patients: (1) foods rich in lutein and zeaxanthin, (2) a lutein or zeaxanthin supplement, (3) a vitamin A or beta-carotene supplement, (4) a vitamin C supplement, (5) a vitamin E supplement, (6) a zinc supplement, or a (7) multi-vitamin/mineral supplement. Patients were divided into five categories: (1) patients not at risk of AMD or cataract, (2) patients at risk of AMD, (3) patients at risk of cataract, (4) patients diagnosed with AMD, and (5) patients diagnosed with cataract. A follow-up question was placed after the item addressing the recommendation of a vitamin A or beta-carotene supplement. Respondents who

recommended a vitamin A or beta-carotene supplement were asked if they recommended it to patients who smoked.

The third section referred to the educational or informational materials the optometrist distributed to patients. The first question asked if the optometrist distributed educational or informational materials to patients at his/her practice. If the optometrist distributed educational or informational materials, the next question was whether he/she had educational or informational materials on lutein and zeaxanthin. If the optometrist had educational or informational materials on lutein and zeaxanthin, the next item asked the respondent to mark all the places where educational or informational materials on lutein and zeaxanthin were obtained. If the optometrist did not distribute educational or informational materials to patients at his/her practice or did not have educational or informational materials on lutein and zeaxanthin, the respondent was asked to rank his/her top three reasons for not distributing educational or informational materials on lutein and zeaxanthin. The last question in this section used a 7-point scale to determine the importance to the optometrist of having educational or informational materials on lutein and zeaxanthin to give to patients.

The fourth section of the survey included three demographic questions and a comment section. The first question asked for the gender of the optometrist. The next question asked the number of years the respondent had been practicing optometry (rounded to the closest year). The last question asked the age of the optometrist. The survey concluded by asking respondents to comment if they felt that there was something missing from the survey regarding the topic of lutein and zeaxanthin and eye health.

### *Data Collection Procedures*

Permission from the Institutional Review Board of the University of Wisconsin-Stout was granted before data collection began. This research project was partially funded through an award from the University of Wisconsin-Stout Student Research Fund. The letter of consent and the 20-item survey was sent on May 19, 2003 with a requested response date of June 2, 2003. Postcards were sent on May 30, 2003 to remind optometrists to complete and return the survey with the date extended to June 13, 2003 (Appendix C). In addition, a reminder to return the survey was published in the June issue of the Wisconsin Optometric Association's monthly newsletter.

### *Data Analysis*

This study was descriptive in design. The majority of survey items were nominal variables. The researcher coded the survey variables then entered and analyzed the data using The Statistical Program for Social Sciences (SPSS) version 11.5 for Windows. Data were analyzed for descriptive statistics including frequency, percentage, mode, median, range of scores, mean, and standard deviation. Cross-tabulations were calculated to describe the data more fully.

### *Limitations*

The present study was limited in the sample size, research population, and survey design. The sample selected to receive the mailed survey represented only 38% of the total population of licensed Wisconsin optometrists. The research sample was selected from the total population of licensed Wisconsin optometrists. Therefore, inferences from the results should not be applied to optometrists nation-wide or ophthalmologists, who also provide eye care to patients. Data were

collected via an original survey instrument. Since this survey was designed for this study, there are no measures of validity or reliability.

## Chapter IV: Results

### *Introduction*

The purpose of this study was to determine the perceptions, recommendations, and educational materials of licensed Wisconsin optometrists regarding the relationship between lutein and zeaxanthin and eye health. A 20-item survey was mailed to 300 randomly chosen licensed Wisconsin optometrists. This chapter will describe demographic information, item analysis, selected item response by gender, response analysis within items, and research objectives.

### *Demographic Information*

A one-page survey was sent to 300 optometrists on May 19, 2003, which was followed by a reminder postcard 11 days later. A total of 128 surveys were returned. Of those surveys, 127 were completed and one survey was returned because the address had changed and forwarding time had expired. Similarly, two postcards were returned due to the same reason. Two optometrists who reported that they only received the postcard contacted the researcher by phone to request another survey, which was resent. Therefore, it is estimated that 297 optometrists received both the survey and reminder postcard. The response rate was 42.3%. This represented 16.0% of the total population of licensed optometrists in Wisconsin at that time.

The fourth section of the survey included three demographic items, which will be discussed here. The first item in this section ( $n = 127$ ) asked “What is your gender?” Ninety-five (74.8%) of the participants were male and 31 (24.4%) were female.

Table 4 presents the response to the question “How many years have you been practicing optometry?” Respondents were asked to round to the closest year. The number of years practicing optometry ranged from two years to 45 years. The mean and median number of years

practicing optometry were 16.9 years and 17.0 years, respectively. There was a standard deviation of 9.6 years. The data were bimodal with 20 years and 23 years being tied (6.3%) as the most frequently reported number of years practicing optometry. Five years and 11 years were tied (5.5%) as the second most frequently reported number of years practicing optometry.

Table 4  
How many years have you been practicing optometry? (round to closest year) ( $n = 127$ )

Years	$n$	%
0 to 4	14	11.0
5 to 9	17	13.4
10 to 14	25	19.7
15 to 19	18	14.2
20 to 24	21	16.5
25 to 29	13	10.2
30 to 34	13	10.2
35 to 39	2	1.6
40 to 44	1	0.8
45 to 49	1	0.8

*Note.* Respondents wrote in their years practicing. Responses have been grouped.

Table 5 presents the response to the question “What is your age?” The mean and median ages of the optometrists were 43.6 years and 43.5 years, respectively. There was a standard deviation of 9.1 years. Ages ranged from 28 years to 70 years. The most frequently reported age of the optometrists was 44 years (6.3%) with 37 years, 39 years, and 55 years tied for second (5.5%).

Table 5  
What is your age? ( $n = 127$ )

Years	$n$	%
25 to 29	4	3.1
30 to 34	16	12.6
35 to 39	30	23.6
40 to 44	20	15.7
45 to 49	16	12.6
50 to 54	21	16.5
55 to 59	13	10.2
60 to 64	3	2.4
65 to 69	0	0.0
70 to 74	1	0.8

*Note.* Respondents wrote in their ages in years. Responses have been grouped.

### *Item Analysis*

This portion of the chapter will provide an analysis of the data from the first three sections of the survey which include information on lutein and zeaxanthin and eye health, nutritional recommendations to patients, and educational or informational materials distributed to patients. Data from the fourth section of the survey were described above except for a request for comments at the conclusion of the survey, which said

We are interested in your perceptions of lutein and zeaxanthin and eye health. If you feel that there is something missing from this survey that should have been asked to practicing optometrists regarding the topic of lutein and zeaxanthin and eye health, please comment below.

These comments are included in Appendix D. Statistics will be limited to frequencies and percentages as the data are nominal and ordinal. After each item is described, cross-tabulations between items will be utilized to provide more detail about responses within selected items.

### *Information on Lutein and Zeaxanthin and Eye Health*

The first section of the survey included four items. Table 6 presents the results to the question “How informed do you feel about the relationship between lutein and zeaxanthin and eye health?” No ( $n = 0$ ) optometrists were uninformed, 20 (15.7%) were somewhat informed, 53 (41.7%) were moderately informed, 45 (35.4%) were very informed, and 7 (5.5%) were extremely informed. The majority ( $n = 98$ , 77.2%) of optometrists were moderately to very informed about the relationship between lutein and zeaxanthin and eye health.

Table 6  
How informed do you feel about the relationship  
between lutein and zeaxanthin and eye health?  
(check one) ( $n = 127$ )

Response	<i>n</i>	%
Uninformed	0	0.0
Somewhat informed	20	15.7
Moderately informed	53	41.7
Very informed	45	35.4
Extremely Informed	7	5.5

Table 7 shows the response to the question “Where have you obtained information on the relationship between lutein and zeaxanthin and eye health?” Respondents were asked to check all that applied. Optometrists obtained information from the following: 27 (21.3%) from the TV, newspaper, radio, 22 (17.3%) from the Internet, 55 (43.3%) from colleagues, 63 (49.6%) from pharmaceutical companies or representatives, 114 (89.8%) from studies published in professional journals, 102 (80.3%) from materials published by professional organizations or obtained at professional meetings, 30 (23.6%) from the National Eye Institute, 25 (19.7%) from non-profit organizations dedicated to preventing age-related eye disease, and 7 (5.5%) from other sources. These other sources were continuing education ( $n = 3$ , 2.4%), a lecture ( $n = 2$ , 1.6%), the Physician’s Desk Reference for Nutritional Supplements ( $n = 1$ , 0.8%), and PubMed ( $n = 1$ , 0.8%). The top three obtained sources of information on the relationship between lutein and

zeaxanthin and eye health were: (1) studies published in professional journals, (2) materials published by professional organizations or obtained at professional meetings, and (3) pharmaceutical companies or representatives.

Table 7  
Where have you obtained information on the relationship between lutein and zeaxanthin and eye health? (check all that apply) ( $n = 127$ )

Response	<i>n</i>	%
TV, newspaper, radio	27	21.3
Internet	22	17.3
Colleagues	55	43.3
Pharmaceutical companies or representatives	63	49.6
Studies published in professional journals	114	89.8
Materials published by professional organizations or obtained at professional meetings	102	80.3
National Eye Institute (NEI)	30	23.6
Non-profit organizations dedicated to preventing age-related eye disease	25	19.7
Other	7	5.5

Table 8 shows the results to “Using a scale of 1 to 3, please rank your top 3 most preferred sources of information on lutein and zeaxanthin and eye health.” Eighty-three (65.4%) preferred studies published in professional journals, 24 (18.9%) preferred materials published by professional organizations or obtained at professional meetings, and 5 (3.9%) preferred the National Eye Institute as their most preferred source of information on lutein and zeaxanthin and eye health. Sixty-three (49.6%) preferred materials published by professional organizations or obtained at professional meetings, 24 (18.9%) preferred studies in professional journals, and 9 (7.1%) preferred the National Eye Institute as their second most preferred source of information on lutein and zeaxanthin and eye health. Thirty-two (25.2%) preferred pharmaceutical companies or representatives, 22 (17.3%) preferred colleagues, and 21 (16.5%) preferred the National Eye Institute as their third most preferred source of information on lutein and zeaxanthin and eye

health. Continuing education ( $n = 4$ , 3.1%) and an educational lecture or course ( $n = 1$ , 0.8%) were preferred sources of information on lutein and zeaxanthin and eye health in the “other” category. The most frequently preferred sources of information on lutein and zeaxanthin and eye health were: (1) studies published in professional journals ( $n = 113$ , 89.0%), (2) materials published by professional organizations or obtained at professional meetings ( $n = 107$ , 84.2%), and (3) pharmaceutical companies or representatives ( $n = 42$ , 33.1%). It appears that optometrists have obtained information from their preferred sources.

Table 8  
Using a scale of 1 to 3, please rank your top 3 most preferred sources of information on lutein and zeaxanthin and eye health. ( $n = 127$ )

Response	Rank	<i>n</i>	%
TV, newspaper, radio	1	1	0.8
	2	2	1.6
	3	4	3.1
Internet	1	3	2.4
	2	2	1.6
	3	1	0.8
Colleagues	1	2	1.6
	2	7	5.5
	3	22	17.3
Pharmaceutical companies or representatives	1	3	2.4
	2	7	5.5
	3	32	25.2
Studies published in professional journals	1	83	65.4
	2	24	18.9
	3	6	4.7
Materials published by professional organizations or obtained at professional meetings	1	24	18.9
	2	63	49.6
	3	20	15.7
National Eye Institute (NEI)	1	5	3.9
	2	9	7.1
	3	21	16.5
Non-profit organizations dedicated to preventing age-related eye disease	1	1	0.8
	2	5	3.9
	3	13	10.2
Other: Continuing education	1	2	1.6
	2	2	1.6
Other: Educational lecture or course	2	1	0.8

The next item asked “Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients?” Ninety-nine (78.0%) indicated the information on lutein and zeaxanthin and eye health was adequate, 16 (12.6%) indicated the information was not adequate while 12 (9.4%) indicated they were not sure if the information was adequate for them to make recommendations to patients.

#### *Nutritional Recommendations to Patients*

The second section of the survey included eight items. For each of the eight items, respondents were given six options. These included “patients not at risk of AMD or cataract,” “patients at risk of AMD,” “patients at risk of cataract,” “patients diagnosed with AMD,” or “patients diagnosed with cataract.” If the optometrist did not recommend the foods or supplement, an option was given that said “I have not recommended [the foods or supplement] to patients.” Item number eight was an exception, which asked “If you recommend a vitamin A or beta-carotene supplement to patients, do you recommend it to patients who smoke?” A summary of these data are shown in Table 9 by subgroup.

Table 9  
I recommend [foods or supplements] to patients [subgroup] ( $n = 127$ )

Response	Subgroup				
	NAR	RAMD	RC	DAMD	DC
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Spinach	16 (12.6)	99 (78.0)	20 (15.7)	101 (79.5)	19 (15.0)
Lutein	7 (5.5)	96 (75.6)	10 (7.9)	103 (81.1)	13 (10.2)
Vitamin A	11 (8.7)	72 (56.7)	15 (11.8)	85 (66.9)	18 (14.2)
Vitamin C	14 (11.0)	49 (38.6)	27 (21.3)	58 (45.7)	28 (22.0)
Vitamin E	16 (12.6)	57 (44.9)	18 (14.2)	66 (52.0)	17 (13.4)
Zinc	9 (7.1)	85 (66.9)	8 (6.3)	101 (79.5)	9 (7.1)
Multi-vitamin	40 (31.5)	100 (78.7)	44 (34.6)	100 (78.7)	42 (33.1)

*Note.* NAR = not at risk of AMD or cataract; RAMD = at risk of AMD; RC = at risk of cataract; DAMD = diagnosed with AMD; DC = diagnosed with cataract.

The first item in this section said “I recommend spinach or other foods rich in lutein and zeaxanthin to.” Table 10 presents the data as respondents who recommended the foods or supplements to any patients. One hundred-nine (85.8%) recommended and 18 (14.2%) had not recommended spinach or foods rich in lutein and zeaxanthin to patients. Most respondents recommended spinach or other foods rich in lutein and zeaxanthin to those at risk ( $n = 99$ , 78.0%) or those diagnosed ( $n = 101$ , 79.5%) with AMD.

The next item said “I recommend a lutein or zeaxanthin supplement to.” One hundred-ten (86.6%) recommended and 16 (12.6%) had not recommended a lutein or zeaxanthin supplement to patients. Most respondents recommended a lutein or zeaxanthin supplement to those at risk ( $n = 96$ , 75.6%) or those diagnosed ( $n = 103$ , 81.1%) with AMD.

The next item said “I recommend a vitamin A or beta-carotene supplement to.” Ninety-five (74.8%) recommended and 32 (25.2%) had not recommended a vitamin A or beta-carotene supplement to patients. Most respondents recommended a vitamin A or beta-carotene supplement to those at risk ( $n = 72, 56.7\%$ ) or those diagnosed ( $n = 85, 66.9\%$ ) with AMD.

The next item asked “If you recommend a vitamin A or beta-carotene supplement to patients, do you recommend it to patients who smoke?” Of those who recommended a vitamin A or beta-carotene supplement ( $n = 95$ ), 25 (26.3%) recommended and 66 (69.5%) had not recommended a vitamin A or beta-carotene supplement to patients who smoke.

The next item said “I recommend a vitamin C supplement to.” Seventy-five (59.1%) recommended and 52 (40.9%) had not recommended a vitamin C supplement to patients. Less than half of respondents recommended a vitamin C supplement to those at risk ( $n = 49, 38.6\%$ ) or those diagnosed ( $n = 58, 45.7\%$ ) with AMD.

The next item said “I recommend a vitamin E supplement to.” Seventy-four (58.3%) recommended and 52 (40.9%) had not recommended a vitamin E supplement to patients. Less than half of respondents recommended a vitamin E supplement to those at risk of AMD ( $n = 57, 44.9\%$ ) while more than half recommended it to those diagnosed with AMD ( $n = 66, 52.0\%$ ).

The next item said “I recommend a zinc supplement to.” One hundred-eight (85.0%) recommended and 19 (15%) had not recommended a zinc supplement to patients. Most respondents recommended a zinc supplement to those at risk ( $n = 85, 66.9\%$ ) or those diagnosed ( $n = 101, 79.5\%$ ) with AMD.

The last item said “I recommend a multi-vitamin/mineral supplement to.” One hundred-sixteen (91.3%) recommended and 11 (8.7%) had not recommended a multi-vitamin/mineral supplement to patients. Most respondents recommended a multi-vitamin/mineral supplement to

those at risk ( $n = 100$ , 78.7%) or those diagnosed ( $n = 100$ , 78.7%) with AMD. A multi-vitamin/mineral supplement was the most recommended foods or supplement to those not at risk of AMD or cataract. The most recommended foods or supplements were a multi-vitamin/mineral supplement ( $n = 116$ , 91.3%), a lutein or zeaxanthin supplement ( $n = 110$ , 86.6%), spinach or foods rich in lutein or zeaxanthin ( $n = 109$ , 85.8%), and a zinc supplement ( $n = 108$ , 85%).

Table 10  
I recommend [foods or supplements] to [any] patients ( $n = 127$ )

Response	<i>n</i>	%
Spinach or other foods		
Yes	109	85.8
No	18	14.2
Lutein or zeaxanthin		
Yes	110	86.6
No	16	12.6
Vitamin A or beta-carotene		
Yes	95	74.8
No	32	25.2
Vitamin C		
Yes	75	59.1
No	52	40.9
Vitamin E		
Yes	74	58.3
No	52	40.9
Zinc		
Yes	108	85.0
No	19	15.0
Multi-vitamin/mineral		
Yes	116	91.3
No	11	8.7

#### *Educational or Informational Materials Distributed to Patients*

The third section of the survey included five items. The first item in this section asked “Do you currently distribute educational or informational materials to patients at your practice?” One hundred-one (79.5%) currently distributed and 25 (19.7%) did not currently distribute educational or informational materials to patients at their practice in May/June of 2003.

The next item asked “Do you have educational or informational materials on lutein and zeaxanthin?” Of those who were distributing educational or informational materials ( $n = 101$ ), 51 (50.5%) had educational or informational materials and 50 (49.5%) did not have educational or informational materials on lutein and zeaxanthin.

Table 11 presents the results to the question “Where have you obtained your educational or informational materials on lutein and zeaxanthin?” Optometrists obtained materials from the following: 26 (51.0%) from the American Optometric Association, 18 (35.3%) from the National Eye Institute, 10 (19.6%) from the American Academy of Ophthalmology, 12 (23.5%) from the American Macular Degeneration Foundation, 7 (13.7%) from the Alliance for Aging Research, 24 (47.1%) from pharmaceutical companies, 12 (23.5%) developed their own, and 11 (21.6%) from other sources. These other sources were 1 (2.0%) from an ophthalmology newsletter, 1 (2.0%) from an article by an M.D., 3 (5.9%) from a Journal, 1 (2.0%) from commercially available patient pamphlets, 1 (2.0%) from another optometrist, 1 (2.0%) from Research to Prevent Blindness, 1 (2.0%) from PubMed, 1 (2.0%) from the American Academy of Optometry, and 1 (2.0%) from an ophthalmology group. The most frequently obtained sources of educational or informational materials on lutein and zeaxanthin were (1) the American Optometric Association, (2) pharmaceutical companies, and (3) the National Eye Institute.

Table 11  
Where have you obtained your educational or informational materials on lutein and zeaxanthin? (check all that apply) ( $n = 51$ )

Response	<i>n</i>	%
American Optometric Association	26	51.0
National Eye Institute (NEI)	18	35.3
American Academy of Ophthalmology	10	19.6
American Macular Degeneration Foundation	12	23.5
Alliance for Aging Research	7	13.7
Pharmaceutical companies	24	47.1
I develop my own	12	23.5
Other	11	21.6

Table 12 shows the results to “If you currently do not distribute educational or informational materials on lutein and zeaxanthin, using a scale of 1 to 3, please rank your top 3 reasons for not distributing educational or informational materials on lutein and zeaxanthin.” Thirty-one (41.3%) marked “unsure of where to obtain,” 18 (24.0%) marked “I would rather answer questions directly,” and 17 (22.7%) marked “research is limited” as their most important reason for not distributing educational or informational materials on lutein and zeaxanthin. Twelve marked “time to obtain, develop, or reproduce” (16.4%), 12 marked “I would rather answer questions directly” (16.0%), and 10 (13.3%) marked “research is limited” as the second most important reason for not distributing educational or information materials on lutein and zeaxanthin. Ten (13.7%) marked “time to obtain, develop, or reproduce,” 9 (12.2%) marked “cost to obtain, develop, or reproduce,” and 7 each marked “unsure of where to obtain” (9.3%) and “research is limited” (9.3%) as the third most important reason for not distributing educational or informational materials on lutein and zeaxanthin. The most frequent reasons for not distributing educational or informational materials on lutein and zeaxanthin were: (1) “unsure of where to obtain” ( $n = 43$ , 57.3%), (2) “I would rather answer questions directly” ( $n = 35$ ,

46.7%), (3) “research is limited” ( $n = 34$ , 45.3%), and (4) “time to obtain, develop, or reproduce” ( $n = 27$ , 37.0%). One respondent (1.3%) each specified the following four “other” reasons for not distributing educational or informational materials on lutein and zeaxanthin: an unspecified other reason, “lutein and zeaxanthin is included with other topic in my handout,” “would like to have samples,” and “misinformation is being passed around...” It should be noted that several respondents who had materials on lutein and zeaxanthin responded to this item. These responses were included in this item’s total because these respondents may not be distributing the materials on lutein and zeaxanthin to patients.

Table 12

If you currently do not distribute educational or informational materials on lutein and zeaxanthin, using a scale of 1 to 3, please rank your top 3 reasons for not distributing educational or informational materials on lutein and zeaxanthin.

Response	Rank	<i>n</i>	%
Unsure of where to obtain <sup>c</sup>	1	31	41.3
	2	5	6.7
	3	7	9.3
I would rather answer questions directly <sup>c</sup>	1	18	24.0
	2	12	16.0
	3	5	6.7
Not my responsibility <sup>d</sup>	1	0	0.0
	2	0	0.0
	3	1	1.3
No patient interest <sup>d</sup>	1	0	0.0
	2	2	2.6
	3	4	5.3
Cost to obtain, develop, or reproduce <sup>b</sup>	1	1	1.4
	2	8	10.8
	3	9	12.2
Time to obtain, develop, or reproduce <sup>a</sup>	1	5	6.8
	2	12	16.4
	3	10	13.7
Research is limited <sup>c</sup>	1	17	22.7
	2	10	13.3
	3	7	9.3
Available materials either have too small print or are above the reading level of my patients <sup>d</sup>	1	1	1.3
	2	1	1.3
	3	3	3.9
Other: Unspecified <sup>b</sup>	1	0	0.0
	2	0	0.0
	3	1	1.3
Other: Lutein and zeaxanthin is included with other topic in my handout <sup>d</sup>	1	0	0.0
	2	1	1.3
	3	0	0.0
Other: Would like to have samples <sup>d</sup>	1	0	0.0
	2	1	1.3
	3	0	0.0
Other: Misinformation is being passed around <sup>d</sup>	1	0	0.0
	2	0	0.0
	3	1	1.3

<sup>a</sup> *n* = 73. <sup>b</sup> *n* = 74. <sup>c</sup> *n* = 75. <sup>d</sup> *n* = 76.

Table 13 listed the results to “How important is it to you to have educational or informational materials on lutein and zeaxanthin to give to your patients?” The following responses were received: 14 (11.0%) marked extremely important, 32 (25.2%) marked very important, 50 (39.4%) marked somewhat important, 22 (17.3%) marked undecided, 4 (3.1%) marked somewhat unimportant, 3 (2.4%) marked very unimportant and no one marked extremely unimportant. It was somewhat to very important for the majority of optometrists ( $n = 82$ , 64.6%) to have educational or informational materials on lutein and zeaxanthin to give to their patients.

Table 13  
How important is it to you to have educational or informational materials on lutein and zeaxanthin to give to your patients? ( $n = 127$ )

Response	<i>n</i>	%
Extremely important	14	11.0
Very important	32	25.2
Somewhat important	50	39.4
Undecided	22	17.3
Somewhat unimportant	4	3.1
Very unimportant	3	2.4
Extremely unimportant	0	0.0

#### *Selected Item Response by Gender*

Gender of the optometrist was cross-tabulated with selected survey items to compare responses between genders. From a total of 124 respondents (94 male, 30 female), females felt slightly more informed than males about the relationship between lutein and zeaxanthin and eye health (Table 14). Eighty percent ( $n = 24$ ) of females were moderately to very informed compared to 77.6% ( $n = 73$ ) of males. Men ( $n = 17$ , 18.1%) were more somewhat informed than women ( $n = 3$ , 10.0%) while women ( $n = 3$ , 10.0%) were more extremely informed than men ( $n = 4$ , 4.3%).

Table 14

How informed do you feel about the relationship between lutein and zeaxanthin and eye health? within gender ( $n = 124$ )

Gender	Response				
	Uninformed	Somewhat	Moderately	Very	Extremely
Male					
<i>n</i>	0	17	38	35	4
% within	0.0	18.1	40.4	37.2	4.3
Female					
<i>n</i>	0	3	14	10	3
% within	0.0	10.0	46.7	33.3	10.0

From a total of 126 respondents (95 male, 31 female), a higher percentage of females ( $n = 27$ , 87.1%) than males ( $n = 72$ , 75.8%) thought the information on lutein and zeaxanthin and eye health was adequate for them to make recommendations to patients (Table 15). Both genders were similar in the percentage of those who were not sure if the information was adequate (males:  $n = 9$ , 9.5%; females:  $n = 3$ , 9.7%).

Table 15

Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? within gender ( $n = 126$ )

Gender	Response		
	Yes	No	Not sure
Male			
<i>n</i>	72	14	9
% within	75.8	14.7	9.5
Female			
<i>n</i>	27	1	3
% within	87.1	3.2	9.7

From a total of 125 to 126 respondents (53 to 85 male, 17 to 30 female), most of the supplements were recommended at a higher percentage by females than males (Table 16). Females recommended spinach or other foods rich in lutein and zeaxanthin (males:  $n = 81$ , 85.3%; females:  $n = 28$ , 90.3%), a vitamin A or beta-carotene supplement (males:  $n = 70$ , 73.7%; females:  $n = 25$ , 80.6%), a vitamin C supplement (males:  $n = 53$ , 55.8%; females:  $n = 22$ ,

71.0%), and a multi-vitamin/mineral supplement (males:  $n = 85$ , 89.5%; females:  $n = 30$ , 96.8%) at a higher percentage than males. Men recommended a vitamin E supplement (males:  $n = 57$ , 60.6%; females:  $n = 17$ , 54.8%) and a zinc supplement (males:  $n = 83$ , 87.4%; females:  $n = 25$ , 80.6%) at a higher percentage than females. Recommendation of a lutein or zeaxanthin supplement was similar between genders (males:  $n = 83$ , 88.3%; females:  $n = 27$ , 87.1%).

Table 16  
I recommend [foods or supplements] to patients within gender

Gender	Response						
	Spinach <sup>b</sup>	Lutein <sup>a</sup>	Vitamin A <sup>b</sup>	Vitamin C <sup>b</sup>	Vitamin E <sup>a</sup>	Zinc <sup>b</sup>	Multi-vit <sup>b</sup>
Male							
<i>n</i>	81	83	70	53	57	83	85
% within	85.3	88.3	73.7	55.8	60.6	87.4	89.5
Female							
<i>n</i>	28	27	25	22	17	25	30
% within	90.3	87.1	80.6	71.0	54.8	80.6	96.8

<sup>a</sup>  $n = 125$ . <sup>b</sup>  $n = 126$ .

In contrast to the gender results from the first three cross-tabulations, there is a larger difference in gender response when respondents were asked about having or the importance of having educational or informational materials to give to patients. From a total of 126 respondents (95 male, 31 female), a higher percentage of females ( $n = 30$ , 96.8%) than males ( $n = 71$ , 74.7%) currently distributed educational or informational materials to patients at their practice in May/June 2003 (Table 17). Of those that distributed educational or informational materials ( $n = 101$ ), a higher percentage of males ( $n = 42$ , 59.2%) than females ( $n = 9$ , 30.0%) had educational or informational materials on lutein and zeaxanthin (Table 18).

Table 17  
Do you currently distribute educational or informational materials to patients at your practice? within gender ( $n = 126$ )

Gender	Response	
	Yes	No
Male		
<i>n</i>	71	24
% within	74.7	25.3
Female		
<i>n</i>	30	1
% within	96.8	3.2

Table 18  
Do you have educational or informational materials on lutein and zeaxanthin? within gender ( $n = 101$ )

Gender	Response	
	Yes	No
Male		
<i>n</i>	42	29
% within	59.2	40.8
Female		
<i>n</i>	9	21
% within	30.0	70.0

From a total of 125 respondents (94 male, 31 female), it was more important to females than males to have educational or informational materials on lutein and zeaxanthin to give to their patients (Table 19). It was somewhat to very important to 71.0% ( $n = 22$ ) of females compared to 63.8% ( $n = 60$ ) of males. Only men thought it was unimportant to have educational or informational materials on lutein and zeaxanthin to give to their patients: somewhat to very unimportant to 7.4% ( $n = 7$ ).

Table 19  
How important is it to you to have educational or informational materials on lutein and zeaxanthin to give to your patients? within gender ( $n = 125$ )

Gender	Response						
	Important			Undecided	Unimportant		
	Extremely	Very	Somewhat		Somewhat	Very	Extremely
Male							
<i>n</i>	10	26	34	17	4	3	0
% within	10.6	27.7	36.2	18.1	4.3	3.2	0.0
Female							
<i>n</i>	4	6	16	5	0	0	0
% within	12.9	19.4	51.6	16.1	0.0	0.0	0.0

#### *Response Analysis within Items*

Where respondents obtained information on the relationship between lutein and zeaxanthin and eye health (item number two) was compared with how informed respondents felt about the relationship between lutein and zeaxanthin and eye health (item number one). The data are presented in Table 20. Those who obtained information from the internet had the highest percentage of extremely informed respondents ( $n = 5, 22.7\%$ ) compared to those who obtained information elsewhere. Those who obtained information from the National Eye Institute had the highest percentage of very informed respondents ( $n = 15, 51.7\%$ ) compared to those who obtained information elsewhere. Those who obtained information from colleagues had the highest percentage of moderately informed respondents ( $n = 25, 46.3\%$ ) compared to those who obtained information elsewhere. And those who obtained information from the TV, newspaper, radio had the highest percentage of somewhat informed respondents ( $n = 6, 23.1\%$ ) compared to those who obtained information elsewhere. None of these results include the “other” category due to limited response.

Table 20

How informed do you feel about the relationship between lutein and zeaxanthin and eye health? within Where have you obtained information on the relationship between lutein and zeaxanthin and eye health?

Response to obtained	Response to how informed				
	Uninformed	Somewhat	Moderately	Very	Extremely
TV					
<i>n</i>	0	6	11	7	2
% within	0.0	23.1	42.3	26.9	7.7
Internet					
<i>n</i>	0	1	7	9	5
% within	0.0	4.5	31.8	40.9	22.7
Colleagues					
<i>n</i>	0	8	25	17	4
% within	0.0	14.8	46.3	31.5	7.4
Pharm					
<i>n</i>	0	7	22	28	5
% within	0.0	11.3	35.5	45.2	8.1
Studies					
<i>n</i>	0	16	44	45	7
% within	0.0	14.3	39.3	40.2	6.3
Materials					
<i>n</i>	0	12	43	40	6
% within	0.0	11.9	42.6	39.6	5.9
NEI					
<i>n</i>	0	2	6	15	6
% within	0.0	6.9	20.7	51.7	20.7
Non-profit					
<i>n</i>	0	1	6	12	5
% within	0.0	4.2	25.0	50.0	20.8
Lecture					
<i>n</i>	0	0	2	0	0
% within	0.0	0.0	100.0	0.0	0.0
CPE					
<i>n</i>	0	1	1	0	0
% within	0.0	50.0	50.0	0.0	0.0
PDR					
<i>n</i>	0	0	0	0	1
% within	0.0	0.0	0.0	0.0	100.0
PubMed					
<i>n</i>	0	0	0	1	0
% within	0.0	0.0	0.0	100.0	0.0

*Note.* TV = TV, newspaper, radio; Pharm = pharmaceutical companies or representatives; Studies = studies published in professional journals; Materials = materials published by professional organizations or obtained

Table 20 Continued

at professional meetings; NEI = National Eye Institute; Non-profit = non-profit organizations dedicated to preventing age-related eye disease; CPE = continuing education; PDR = physicians desk reference for nutritional supplements.

The perceived adequacy of the information on lutein and zeaxanthin and eye health to make recommendations to patients (item number four) was compared with how informed respondents felt about the relationship between lutein and zeaxanthin and eye health (item number one). Results are found in Table 21. The majority of optometrists who thought the information was adequate to make recommendations to patients ( $n = 97$ ) were moderately to very informed ( $n = 82, 84.5\%$ ) while the majority of those who thought the information was not adequate ( $n = 16$ ) were somewhat to moderately informed ( $n = 15, 93.7\%$ ).

Table 21

How informed do you feel about the relationship between lutein and zeaxanthin and eye health? within Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? ( $n = 125$ )

Response to adequate	Response to how informed				
	Uninformed	Somewhat	Moderately	Very	Extremely
Yes					
<i>n</i>	0	8	41	41	7
% within	0.0	8.2	42.3	42.3	7.2
No					
<i>n</i>	0	8	7	1	0
% within	0.0	50.0	43.8	6.3	0.0
Not sure					
<i>n</i>	0	4	5	3	0
% within	0.0	33.3	41.7	25.0	0.0

The recommendations of optometrists for spinach or other foods rich in lutein and zeaxanthin (item number five) and for a lutein or zeaxanthin supplement (item number six) were compared with the perceived adequacy of the information on lutein and zeaxanthin and eye health to make recommendations to patients (item number four). The results are shown in Tables 22 and 23. Those who recommended spinach or other foods rich in lutein and zeaxanthin to

patients ( $n = 109$ ) were more likely ( $n = 88, 80.7\%$ ) to indicate the information on lutein and zeaxanthin and eye health was adequate to make recommendations compared to those who did not recommend spinach ( $n = 11, 61.1\%$ ). Those who did not recommend a lutein or zeaxanthin supplement were more likely to indicate the information on lutein and zeaxanthin and eye health was not adequate to make recommendations to patients ( $n = 10, 62.5\%$ ) compared to those who did recommend a lutein or zeaxanthin supplement ( $n = 6, 5.5\%$ ).

Table 22  
Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? within I recommend spinach or other foods rich in lutein and zeaxanthin to patients

Response to recommend spinach	Response to adequate		
	Yes	No	Not sure
Yes			
<i>n</i>	88	9	12
% within	80.7	8.3	11.0
No			
<i>n</i>	11	7	0
% within	61.1	38.9	0.0

Table 23  
Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? within I recommend a lutein or zeaxanthin supplement to patients ( $n = 126$ )

Response to recommend lutein	Response to adequate		
	Yes	No	Not sure
Yes			
<i>n</i>	94	6	10
% within	85.5	5.5	9.1
No			
<i>n</i>	4	10	2
% within	25.0	62.5	12.5

Respondents who recommended foods or supplements to patients (item number five to 12) was cross-tabulated with whether respondents recommended these foods or supplements to

patients at risk or diagnosed with AMD (Table 24). Of those that recommend the foods or supplements in the survey, a majority recommended each of these to patients at risk or diagnosed with AMD.

Table 24  
Patients at risk or diagnosed with AMD within I recommend [foods or supplements] to patients

Response to recommend	Response			
	At Risk of AMD		Diagnosed with AMD	
	Yes	No	Yes	No
<b>Spinach<sup>a</sup></b>				
<i>n</i>	99	10	101	8
% within	90.8	9.2	92.7	7.3
<b>Lutein<sup>b</sup></b>				
<i>n</i>	96	14	103	7
% within	87.3	12.7	93.6	6.4
<b>Vitamin A<sup>c</sup></b>				
<i>n</i>	72	23	85	10
% within	75.8	24.2	89.5	10.5
<b>Vitamin C<sup>d</sup></b>				
<i>n</i>	49	26	58	17
% within	65.3	34.7	77.3	22.7
<b>Vitamin E<sup>e</sup></b>				
<i>n</i>	57	17	66	8
% within	77.0	23.0	89.2	10.8
<b>Zinc<sup>f</sup></b>				
<i>n</i>	85	23	101	7
% within	78.7	21.3	93.5	6.5
<b>Multi-vitamin<sup>g</sup></b>				
<i>n</i>	100	16	100	16
% within	86.2	13.8	86.2	13.8

<sup>a</sup> *n* = 109. <sup>b</sup> *n* = 110. <sup>c</sup> *n* = 95. <sup>d</sup> *n* = 75. <sup>e</sup> *n* = 74. <sup>f</sup> *n* = 108. <sup>g</sup> *n* = 116.

The recommendations of optometrists for spinach or other foods rich in lutein and zeaxanthin (item number five) and for a lutein or zeaxanthin supplement (item number six) was compared with whether optometrists had educational or informational materials on lutein and zeaxanthin (item number 14). Tables 25 and 26 present the results. A slightly higher percentage of optometrists who recommended spinach to patients (*n* = 90) had educational or informational

materials on lutein and zeaxanthin ( $n = 46$ , 51.1%) compared to those who did not recommend ( $n = 11$ ) spinach or other foods rich in lutein and zeaxanthin to patients ( $n = 5$ , 45.5%). On the other hand, optometrists who recommended a lutein or zeaxanthin supplement ( $n = 89$ ) were noticeably more likely to have educational or informational materials on lutein and zeaxanthin ( $n = 48$ , 53.9%) compared to those who do not recommend ( $n = 11$ ) a lutein or zeaxanthin supplement to patients ( $n = 2$ , 18.2%).

Table 25  
Do you have educational or informational materials on lutein and zeaxanthin? within I recommend spinach or other foods rich in lutein and zeaxanthin to patients ( $n = 101$ )

Response to recommend spinach	Response to materials on lutein	
	Yes	No
Yes		
<i>n</i>	46	44
% within	51.1	48.9
No		
<i>n</i>	5	6
% within	45.5	54.5

Table 26  
Do you have educational or informational materials on lutein and zeaxanthin? within I recommend a lutein or zeaxanthin supplement to patients ( $n = 100$ )

Response to recommend lutein	Response to materials on lutein	
	Yes	No
Yes		
<i>n</i>	48	41
% within	53.9	46.1
No		
<i>n</i>	2	9
% within	18.2	81.8

Perceived adequacy of the information on lutein and zeaxanthin and eye health to make recommendations to patients (item number four) was compared with whether optometrists had

educational or informational materials on lutein and zeaxanthin (item number 14). Data are shown in Table 27. From a total of 101 respondents (83 yes, 9 no, 9 not sure), optometrists who thought the information was adequate were more likely ( $n = 46$ , 55.4%) to have educational or informational materials on lutein and zeaxanthin than those who did not think the information was adequate ( $n = 1$ , 11.1%). Those who were not sure if the information on lutein and zeaxanthin was adequate were slightly more likely to not have educational or informational materials on lutein and zeaxanthin ( $n = 5$ , 55.6%) than those who thought the information was adequate ( $n = 37$ , 44.6%).

Table 27  
Do you have educational or informational materials on lutein and zeaxanthin? within Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? ( $n = 101$ )

Response to adequate	Response to materials	
	Yes	No
Yes		
<i>n</i>	46	37
% within	55.4	44.6
No		
<i>n</i>	1	8
% within	11.1	88.9
Not sure		
<i>n</i>	4	5
% within	44.4	55.6

Whether optometrists had educational or informational materials on lutein and zeaxanthin (item number 14) was compared with the importance of having educational or informational materials on lutein and zeaxanthin (item number 17). See Table 28 for results. From a total of 100 respondents (50 yes, 50 no), it was somewhat to extremely important to have educational or informational materials on lutein and zeaxanthin for the majority of optometrists who had materials on lutein and zeaxanthin ( $n = 48$ , 96.0%) while it was undecided to very important to

have materials on lutein and zeaxanthin for most of the optometrists who did not have materials on lutein and zeaxanthin ( $n = 47, 94.0\%$ ).

Table 28

How important is it to you to have educational or informational materials on lutein and zeaxanthin to give to your patients? within Do you have educational or informational materials on lutein and zeaxanthin? ( $n = 100$ )

Response to materials on lutein	Response to how important					
	Extremely	Very	Somewhat	Undecided	Somewhat	Very
Yes						
<i>n</i>	14	19	15	2	0	0
% within	28.0	38.0	30.0	4.0	0.0	0.0
No						
<i>n</i>	0	12	23	12	1	2
% within	0.0	24.0	46.0	24.0	2.0	4.0

### *Research Objectives*

Research Objective #1: Evaluate the awareness, sources of information, and confidence of Wisconsin optometrists on the relationship between diets high in lutein and zeaxanthin and eye health.

The first section of the survey, which included item number one through four, addressed research objective #1. The majority ( $n = 98, 77.2\%$ ) of optometrists were moderately to very informed about the relationship between lutein and zeaxanthin and eye health (Table 6). The top three obtained sources of information on the relationship between lutein and zeaxanthin and eye health were: (1) studies published in professional journals ( $n = 114, 89.8\%$ ), (2) materials published by professional organizations or obtained at professional meetings ( $n = 102, 80.3\%$ ), and (3) pharmaceutical companies or representatives ( $n = 63, 49.6\%$ ) (Table 7). The most frequently preferred sources of information on lutein and zeaxanthin and eye health were: (1) studies published in professional journals ( $n = 113, 89.0\%$ ), (2) materials published by professional organizations or obtained at professional meetings ( $n = 107, 84.2\%$ ), and (3)

pharmaceutical companies or representatives ( $n = 42, 33.1\%$ ) (Table 8). The majority of optometrists ( $n = 99, 78.0\%$ ) indicated the information on lutein and zeaxanthin and eye health was adequate for them to make recommendations to patients.

Research Objective #2: Determine the nutritional recommendations of Wisconsin optometrists for the prevention or treatment of AMD and cataract.

The second section of the survey, which included item number five through 12, focused on research objective #2. The following foods or supplements were recommended by optometrists in descending order: a multi-vitamin/mineral supplement ( $n = 116, 91.3\%$ ), a lutein or zeaxanthin supplement ( $n = 110, 86.6\%$ ), spinach or other foods rich in lutein and zeaxanthin ( $n = 109, 85.8\%$ ), a zinc supplement ( $n = 108, 85.0\%$ ), a vitamin A or beta-carotene supplement ( $n = 95, 74.8\%$ ), a vitamin C supplement ( $n = 75, 59.1\%$ ), and a vitamin E supplement ( $n = 74, 58.3\%$ ) (Table 10). More than half of respondents recommended all foods or supplements in the survey except a vitamin C or vitamin E supplement to those at risk of AMD and except a vitamin C supplement to those diagnosed with AMD (Table 9). None of the foods or supplements in the survey were recommended by a majority of the optometrists to those not at risk of AMD or cataract, those at risk of cataract, or those diagnosed with cataract although about one-third of optometrists recommended a multi-vitamin/mineral supplement to these groups.

Research Objective #3: Assess the availability and importance of educational materials on lutein and zeaxanthin to Wisconsin optometrists.

The third section of the survey, which included item number 13 through 17, investigated research objective #3. Most optometrists were distributing educational or informational materials to patients at their practice ( $n = 101, 79.5\%$ ) although about half ( $n = 51, 50.5\%$ ) of those who were distributing materials had educational or informational materials on lutein and zeaxanthin.

The most frequently obtained sources of educational or informational materials on lutein and zeaxanthin were (1) the American Optometric Association, (2) pharmaceutical companies, and (3) the National Eye Institute (Table 11). The most frequent reasons for not distributing educational or informational materials on lutein and zeaxanthin were: (1) “unsure of where to obtain” ( $n = 43, 57.3\%$ ), (2) “I would rather answer questions directly” ( $n = 35, 46.7\%$ ), (3) “research is limited” ( $n = 34, 45.3\%$ ), and (4) “time to obtain, develop, or reproduce” ( $n = 27, 37.0\%$ ) (Table 12). It was somewhat to very important for the majority of optometrists ( $n = 82, 64.6\%$ ) to have educational or informational materials on lutein and zeaxanthin to give to their patients (Table 13).

Research Objective #4: Summarize the perceptions of Wisconsin optometrists of lutein and zeaxanthin and eye health.

A request for comments located below item number 20 allowed respondents to write their perceptions of lutein and zeaxanthin and eye health or the survey itself (See Appendix D). A few respondents suggested questions they would ask other optometrists while many of the respondents explained why they recommend or do not recommend lutein and zeaxanthin supplements or made reference to the age-related eye disease study (AREDS).

Research Objective #5: Describe the demographic characteristics of Wisconsin optometrists.

The fourth section of the survey, which included item number 18 through 20, looked into research objective #5. Approximately three-fourths (74.8%) of the optometrists were men. The mean age of the optometrists was about 43 years (43.6 years). The youngest respondent was 28 years while the oldest was 70 years. The mean number of years practicing optometry for the

respondents was almost 17 years (16.9 years). The responding optometrists had been practicing from two to 45 years.

## Chapter V: Discussion

### *Introduction*

The purpose of this study was to determine how the perceptions of licensed Wisconsin optometrists toward lutein and zeaxanthin and eye health affected their current practice. This section will include a discussion of the results, limitations, conclusions and recommendations for optometrists, patients and further study.

### *Discussion*

Evidence is accumulating regarding the role of lutein and zeaxanthin in age-related eye disease (Mares-Perlman et al., 2002). Although the evidence is still preliminary as to support the use of spinach as a functional food for prevention and lutein and zeaxanthin supplements for the treatment of age-related eye disease, the consumption of spinach (Lucier, Allshouse, & Lin, 2004) and the popularity of lutein supplements has risen (Kelly et al., 2005). As with any emerging therapy, it is important for health professionals to remain objective in their evaluation of potential treatments for disease and provide accurate, evidence-based advice to patients.

This study investigated the sources of information licensed Wisconsin optometrists obtained on the relationship between lutein and zeaxanthin and eye health. Our results showed studies published in professional journals, materials published by professional organizations or obtained at professional meetings, pharmaceutical companies or representatives, colleagues, and the National Eye Institute to be the top five sources of information on the relationship between lutein and zeaxanthin and eye health. The National Eye Institute's National Eye Health Education Program (NEHEP) Low Vision Focus Groups Final Report found similar results (NEI, 2004). Journal articles, continuing education classes, professional conferences, the internet, and

conversations with colleagues were the most frequent responses to materials that ophthalmologists and optometrists use to educate themselves.

The present study was not the first of its kind. After our study data were collected and analyzed, an internet search found a survey commissioned by Kemin Foods (Des Moines, Iowa), manufacturer of FloraGLO® brand lutein, that assessed the level of awareness, acceptance of and commitment to lutein in 150 randomly chosen ophthalmologists and 150 randomly chosen optometrists in the United States (Young Again Nutrients, 2002; HighBeam Research, Inc., 2002). The study was conducted by Jefferson Davis Associates, an independent research firm in Cedar Rapids, Iowa, in June and July 2001.

Our study found about 86% of optometrists currently recommended spinach or other foods rich in lutein and zeaxanthin to their patients. This was slightly below the results of the Kemin Foods survey (Young Again Nutrients, 2002) in which 90% of ophthalmologists and optometrists believed consumers should eat foods naturally high in lutein such as spinach. Our study showed about 87% of optometrists recommended a lutein or zeaxanthin supplement to patients. Eighty-four percent of ophthalmologists and optometrists in the Kemin Foods survey (Young Again Nutrients) currently recommended lutein to their patients, which is slightly below our results. The most recommended nutritional supplement in our study was a multi-vitamin/mineral supplement (91% of optometrists). This result supports the recommendation of Fletcher and Fairfield (2002) for all adults to take one multivitamin daily. In our study, of those that recommended a multi-vitamin/mineral supplement, about 86% (86.2%) recommended it to those at risk or diagnosed with age-related macular degeneration (AMD). In contrast, while this survey did not ask if optometrists recommended a multi-vitamin/mineral supplement with lutein, the Kemin Foods survey (Young Again Nutrients) found 86% of ophthalmologists and

optometrists believed consumers who take a multivitamin should take one that includes lutein. It is unknown which subgroups the Kemin Foods respondents recommended a multivitamin with lutein for.

We were interested in the educational or informational materials optometrists distributed to patients, particularly those on lutein and zeaxanthin. The most common sources of these materials were obtained from the American Optometric Association, pharmaceutical companies, the National Eye Institute, the American Macular Degeneration Foundation, and from developing their own. Although the NEHEP report (NEI, 2004) found more general sources, these sources appear to be consistent with our results. The most frequent materials NEHEP ophthalmologists and optometrists currently used to educate patients included journal articles, continuing education classes, pamphlets and brochures, videos, the internet, and professional conferences.

### *Limitations*

This study was limited in the sample, population, and study design. First, the research sample was limited in size and by possible bias. The response rate was good although this represented only 16% of the total population of licensed Wisconsin optometrists. Optometrists who chose to respond to the survey may feel more strongly about the relationship between lutein and zeaxanthin and eye health than those who did not respond. Second, the study population was limited to the currently licensed optometrists in Wisconsin. Therefore, inferences from the results should only be applied to licensed Wisconsin optometrists rather than licensed optometrists in other states or nationwide or to ophthalmologists in Wisconsin, other states or nationwide. Third, data collection was via an original survey instrument. Since the survey was designed for this study, there are no measures of validity or reliability. At the time of data collection, the Age-

Related Eye Disease Study (AREDS) was a major eye study in which optometrists were likely to base their nutritional recommendations. Our survey asked optometrists about their recommendations for these vitamins and minerals but each was asked separately. The most recommended supplement was a multi-vitamin/mineral supplement. While the AREDS formulation was a multi-vitamin/mineral supplement, it is not known what percentage of optometrists recommended this specific supplement to patients.

### *Conclusions*

The objectives of this study were met. The first objective was to evaluate the awareness, sources of information, and confidence of Wisconsin optometrists on the relationship between diets high in lutein and zeaxanthin and eye health. The majority of respondents were moderately to very informed about the relationship between lutein and zeaxanthin and eye health (77.2%). Those who obtained information from the internet had the highest percentage of extremely informed respondents (22.7%) compared to those who obtained information elsewhere. The top three obtained sources of information on the relationship between lutein and zeaxanthin and eye health were also the top three most preferred sources of information on lutein and zeaxanthin and eye health. The majority of optometrists thought the information on lutein and zeaxanthin and eye health was adequate for them to make recommendations to patients (78.0%). This percentage was higher among female (87.1%) than male (75.8%) respondents. Most optometrists who thought the information was adequate were moderately to very informed (84.5%) while those who did not think the information was adequate were somewhat to moderately informed (93.7%). These results suggest that the more information optometrists obtained, the more likely they were to find that the information on lutein and zeaxanthin and eye health was adequate to make recommendations to patients.

The second objective was to determine the nutritional recommendations of Wisconsin optometrists for the prevention or treatment of AMD and cataract. The majority of respondents recommended all foods or supplements listed in the survey except a vitamin C supplement to patients diagnosed with AMD and except a vitamin C or vitamin E supplement to patients at risk of AMD. When those who recommended each of the supplements was cross-tabulated with patients at risk or diagnosed with AMD, a majority of the respondents recommended all of these supplements to patients. None of the foods or supplements in the survey were recommended by a majority of the optometrists to patients at risk of cataract or patients diagnosed with cataract. It is concluded that most optometrists recommended a multi-vitamin/mineral supplement to patients at risk or diagnosed with AMD although what formulations and for which stages of AMD are unknown.

The third objective was to assess the availability and importance of educational materials on lutein and zeaxanthin to Wisconsin optometrists. The majority of optometrists were distributing educational or informational materials to patients at their practice (79.5%). Of the respondents who distributed these materials, about half had educational or informational materials on lutein and zeaxanthin (50.5%). Although a higher percentage of female (96.8%) respondents distributed educational or informational materials than males (74.7%), this was reversed for materials on lutein and zeaxanthin (males: 59.2%, females: 30.0%). Optometrists obtained their educational or informational materials on lutein and zeaxanthin from a variety of sources, the most common being the American Optometric Association (51.0%), pharmaceutical companies (47.1%), and the National Eye Institute (35.3%). Of those who did not distribute educational or informational materials on lutein and zeaxanthin, most respondents were unsure of where to obtain these materials (57.3%). It was somewhat to very important for the majority

of optometrists (64.6%) to have educational or informational materials on lutein and zeaxanthin to give to their patients. This percentage was higher among females (71.0%) than males (63.8%). Twenty-eight percent of the optometrists who already had educational or informational materials on lutein and zeaxanthin thought it was extremely important to have educational or informational materials on lutein and zeaxanthin to give to patients compared to none of the optometrists who did not have educational or informational materials on lutein and zeaxanthin. This implies that optometrists will seek out patient materials on lutein and zeaxanthin if it is important to them.

### *Recommendations*

While it is encouraging that none of the respondents in our study were uninformed about the relationship between lutein and zeaxanthin and eye health, a modest amount were only somewhat informed (15.7%). When results of the less informed (somewhat and moderately) and more informed (very and extremely) respondents were split between two groups, there was a majority of less informed (57.5%) compared to the more informed (40.9%) respondents. This supports the need for optometrists to become more informed of the current state of literature on lutein and zeaxanthin and eye health. Future research should focus on the reason optometrists were less informed so appropriate educational strategies can be developed.

It was found that respondents who obtained information from the internet (22.7%), the National Eye Institute (20.7%), and non-profit organizations dedicated to preventing age-related eye disease had the highest percentage of respondents who were extremely informed. These results suggest that optometrists found these to be the most effective sources for obtaining information on the relationship between lutein and zeaxanthin and eye health.

It was interesting to find differences in the availability and importance of educational or informational materials on lutein and zeaxanthin among male and female respondents. Although

a higher percentage of women (96.8%) had educational or informational materials than men (74.7%), men (59.2%) had a higher percentage of educational or informational materials on lutein and zeaxanthin than women (30.0%). A higher percentage of women (83.9%) thought it was somewhat to extremely important to have educational or informational materials on lutein and zeaxanthin to give to patients compared to men (74.5%) while a higher percentage of men (7.4%) thought it was somewhat to very unimportant compared to women (0%). Gender was cross-tabulated with two options from item 16 that asked respondents to rank their top three reasons for not distributing materials on lutein and zeaxanthin (i.e. unsure of where to obtain, I would rather answer questions directly). It is intriguing to note that 30.9% of men ( $n = 17$ ) while only 5.0% of women ( $n = 1$ ) ranked “I would rather answer questions directly” as their most important reason for not distributing educational or informational materials on lutein and zeaxanthin. In addition, 57.9% of women ( $n = 11$ ) and 35.7% of men ( $n = 20$ ) ranked “unsure of where to obtain” as their most important reason for not distributing educational or informational materials on lutein and zeaxanthin.

In summary, it appears that although a higher percentage of women had educational materials and thought it was more important to have these materials than men, a higher percentage of women did not know where to obtain these. On the other hand, it looks as if men were less likely to have educational or informational materials because it was less important to them (although had a higher percentage of materials on lutein and zeaxanthin) and they would rather instruct patients verbally. This shows a need for organizations to publicize the availability of educational or informational materials to optometrists as a majority of female optometrists were unsure of where to obtain these materials. Men may have had more materials on lutein and zeaxanthin because they knew where to obtain these. Optometrists may also find it helpful to

stay connected to services of professional, governmental, and non-profit organizations to improve their current practice. In addition, patients may benefit from having an optometrist who provides information in a format conducive to their learning preference.

In conclusion, this survey attempted to measure several aspects of how lutein and zeaxanthin affected the practice of licensed Wisconsin optometrists. Future research should focus on increasing sample size, including ophthalmologists and modifying the survey to include items that address barriers to obtaining information on nutrition for eye health, recommendations for specific formulations of nutritional supplements, and frequency of referrals to a dietitian. It would also be interesting to do a follow-up survey to compare responses from the original to at least five years post-study.

As research accumulates on the influence of nutrition in the prevention of age-related eye disease, it is anticipated that there will be an increased demand from patients and insurers to provide nutrition education to improve patient outcomes. With the lack of financial incentive for optometrists to provide this type of education, patient educational materials or a referral to a dietitian may be key strategies in improving the ocular and overall health of the patient.

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## Appendix A: Cover Letter

May 19, 2003

Dear Dr. \_\_\_\_\_ ,

I am a graduate student at the University of Wisconsin-Stout and am interested in the relationship between diets high in lutein and zeaxanthin and eye health including the prevention of age-related macular degeneration (AMD) and cataract. For my research study in Food and Nutritional Sciences, I have chosen to send a survey to optometrists in Wisconsin regarding this topic. The objectives of my research are: (1) to evaluate the awareness and sources of information of Wisconsin optometrists on the relationship between lutein and zeaxanthin and eye health; (2) to determine the nutritional recommendations of Wisconsin optometrists for age-related eye disease; and (3) to assess the availability of educational materials on lutein and zeaxanthin to Wisconsin optometrists. Enclosed is a simple, 20-question survey for you to fill out and return in the self-addressed stamped envelope by June 2, 2003. There are no personal identifying questions that will allow me as the researcher to connect your returned survey with you as an individual optometrist. Please note that this survey was designed for currently practicing optometrists. Therefore, if you are not currently practicing, please disregard our request.

It is understood that by returning this survey, you are giving your informed consent as a participating volunteer in this study. The potential risks to you as a practicing optometrist participating in this study are minimal. The potential benefits that might be realized from the successful completion of this study are an increased knowledge of Wisconsin optometrists' sources of information on lutein and zeaxanthin, their nutritional recommendations for age-related eye disease, and their availability of educational materials on lutein and zeaxanthin. The information is being sought in a specific manner so that your anonymity is guaranteed. You have the right to refuse to participate by not returning the survey. Questions or concerns about the research study should be addressed to Tara Larson, the researcher, phone (507) 436-5448, or Janice Coker, the research advisor, phone (715) 232-2239. Questions about the rights of research subjects can be addressed to Sue Foxwell, Human Protections Administrator, UW-Stout Institutional Review Board for the Protection of Human Subjects in Research, 11 Harvey Hall, Menomonie, WI 54751, phone (715) 232-1126.

Your participation in this study is very important to us. Please know that we appreciate your time and are requesting your response by June 2, 2003.

Sincerely,

Tara A. Larson  
Graduate Student  
Department of Food and Nutrition  
University of Wisconsin-Stout

## Appendix B: Survey Instrument

Note: Original survey was one page, printed on both sides of 8.5 inch x 14 inch paper, and organized into four columns.

Please return this survey by June 2, 2003 in the pre-addressed postage-paid envelope provided.

Thank you

Department of Food and Nutrition  
 c/o Tara Larson, graduate student  
 University of Wisconsin-Stout  
 Menomonie, WI 54751-0790  
 Email: [larsontar@uwstout.edu](mailto:larsontar@uwstout.edu)

Several recent studies have indicated a relationship between diets high in lutein and zeaxanthin and eye health including the prevention of age-related macular degeneration (AMD) and cataract.

1. How informed do you feel about the relationship between lutein and zeaxanthin and eye health? (check one)

- Uninformed  
 Somewhat informed  
 Moderately informed  
 Very informed  
 Extremely informed

2. Where have you obtained information on the relationship between lutein and zeaxanthin and eye health? (check all that apply)

- TV, newspaper, radio  
 Internet  
 Colleagues  
 Pharmaceutical companies or representatives  
 Studies published in professional journals  
 Materials published by professional organizations or obtained at professional meetings  
 National Eye Institute (NEI)  
 Non-profit organizations dedicated to preventing age-related eye disease  
 Other (please specify)  
 \_\_\_\_\_  
 I haven't obtained any information.

3. Using a scale of 1 to 3, please RANK YOUR TOP 3 MOST PREFERRED SOURCES of information on lutein and zeaxanthin and eye health.

- TV, newspaper, radio  
 Internet  
 Colleagues  
 Pharmaceutical companies or representatives  
 Studies published in professional journals  
 Materials published by professional organizations or obtained at professional meetings  
 National Eye Institute (NEI)  
 Non-profit organizations dedicated to preventing age-related eye disease  
 Other (please specify)  
 \_\_\_\_\_

4. Is the information on lutein and zeaxanthin and eye health adequate for you to make recommendations to patients? (check one)

- Yes  
 No  
 Not sure

We are interested in your current nutritional recommendations to patients. Please check which patients you recommend the following foods or supplements to. (check all that apply)

5. I recommend spinach or other foods rich in lutein and zeaxanthin to

- Patients NOT at risk of AMD or cataract  
 Patients at risk of AMD  
 Patients at risk of cataract  
 Patients diagnosed with AMD  
 Patients diagnosed with cataract  
 I have not recommended spinach or other foods rich in lutein and zeaxanthin to patients.

6. I recommend a lutein or zeaxanthin supplement to

- Patients NOT at risk of AMD or cataract  
 Patients at risk of AMD  
 Patients at risk of cataract  
 Patients diagnosed with AMD  
 Patients diagnosed with cataract  
 I have not recommended a lutein or zeaxanthin supplement to patients.

7. I recommend a vitamin A or beta-carotene supplement to

- Patients NOT at risk of AMD or cataract  
 Patients at risk of AMD  
 Patients at risk of cataract  
 Patients diagnosed with AMD  
 Patients diagnosed with cataract  
 I have not recommended a vitamin A or beta-carotene supplement to patients.

8. If you recommend a vitamin A or beta-carotene supplement to patients, do you recommend it to patients who smoke?

- Yes  
 No

9. I recommend a vitamin C supplement to

- Patients NOT at risk of AMD or cataract  
 Patients at risk of AMD  
 Patients at risk of cataract  
 Patients diagnosed with AMD  
 Patients diagnosed with cataract  
 I have not recommended a vitamin C supplement to patients.

**10. I recommend a vitamin E supplement to**

- Patients NOT at risk of AMD or cataract
- Patients at risk of AMD
- Patients at risk of cataract
- Patients diagnosed with AMD
- Patients diagnosed with cataract
- I have not recommended a vitamin E supplement to patients.

**11. I recommend a zinc supplement to**

- Patients NOT at risk of AMD or cataract
- Patients at risk of AMD
- Patients at risk of cataract
- Patients diagnosed with AMD
- Patients diagnosed with cataract
- I have not recommended a zinc supplement to patients.

**12. I recommend a multi-vitamin/mineral supplement to**

- Patients NOT at risk of AMD or cataract
- Patients at risk of AMD
- Patients at risk of cataract
- Patients diagnosed with AMD
- Patients diagnosed with cataract
- I have not recommended a multi-vitamin/mineral supplement to patients.

**We are interested in the educational or informational materials you distribute to patients.**

**13. Do you currently distribute educational or informational materials to patients at your practice? (check one)**

- Yes
- No (skip next 2 questions)

**14. Do you have educational or informational materials ON LUTEIN AND ZEAXANTHIN? (check one)**

- Yes
- No (skip next question)

**15. Where have you obtained your educational or informational materials ON LUTEIN AND ZEAXANTHIN? (check all that apply)**

- American Optometric Association
  - National Eye Institute (NEI)
  - American Academy of Ophthalmology
  - American Macular Degeneration Foundation
  - Alliance for Aging Research
  - Pharmaceutical companies
  - I develop my own
  - Other (please specify)
-

**16. IF YOU CURRENTLY DO NOT DISTRIBUTE educational or informational materials ON LUTEIN AND ZEAXANTHIN, using a scale of 1 to 3, please RANK YOUR TOP 3 REASONS for NOT distributing educational or informational materials on lutein and zeaxanthin.**

- Unsure of where to obtain
  - I would rather answer questions directly
  - Not my responsibility
  - No patient interest
  - Cost to obtain, develop, or reproduce
  - Time to obtain, develop, or reproduce
  - Research is limited
  - Available materials either have too small print or are above the reading level of my patients
  - Other (please specify)
- 

**17. How important is it to you to have educational or informational materials ON LUTEIN AND ZEAXANTHIN to give to your patients? (check one)**

- Extremely important
- Very important
- Somewhat important
- Undecided
- Somewhat unimportant
- Very unimportant
- Extremely unimportant

We would like to ask you some demographic questions to better describe the optometrists in our study.

**18. What is your gender?**

- Male
- Female

**19. How many years have you been practicing optometry? (round to closest year)**

years

**20. What is your age?**

years

We are interested in your perceptions of lutein and zeaxanthin and eye health. If you feel that there is something missing from this survey that should have been asked to practicing optometrists regarding the topic of lutein and zeaxanthin and eye health, please comment below.

Thank you for your participation in our study.

## Appendix C: Reminder Postcard

Dear optometrist,

We would like to remind you to complete the survey on lutein and zeaxanthin and eye health we sent you by mail and return it in the postage-paid envelope provided. If you have already returned your completed survey, we would like to thank you for your participation. If you have not yet completed the survey, **we have extended our requested date of return to June 13, 2003.** We hope this will allow you sufficient time to answer our simple 20-question survey. We look forward to receiving your answers. If you are not currently practicing optometry, please disregard our reminder.

If you have any questions or concerns, please contact us at (507) 436-5448, Tara Larson, researcher, or (715) 232-2239, Janice Coker, research advisor.

### Appendix D: Comments from Respondents

We are interested in your perceptions of lutein and zeaxanthin and eye health. If you feel that there is something missing from this survey that should have been asked to practicing optometrists regarding the topic of lutein and zeaxanthin and eye health, please comment below.

Note: Comments were transcribed as closely to original as possible. Therefore, misspelled words were included.

- I feel it is better safe than sorry – if there is a chance of them working against ARM use them.
- I have read a lot regarding lutein but very little on zeaxanthin – would be interesting to know if others felt the same – I answered all questions based on my experience with lutein. – Perhaps you should separate the two.
- The main reason I don't recommend lutein/zeaxanthin is that it was not included in the AREDS (Age Related Eye Disease Study) Study. As I obtain study results confirming the benefits of lutein/zeaxanthin, I would be more willing to recommend it.
- I give information to my ARMD patients on the AREDS study and discuss the added probable benefit of lutein & zeaxanthin/green leafy veg. I don't at this point have material that I distribute with the lutein & zeaxanthin info on it.
- How often do patients specifically ask about lutein & zeaxanthin (Pt interest)
- I think there is not enough scientific data to know for sure if these are helpful for AMD. They have not shown to ↓ incidence of cataract. More research needs to be done.
- You should have asked about recommendations for the specific supplements used in the AREDS study, which DID show clear benefit to some people with AMD.
- Thank you for taking the time and your interest in this area of study. I eagerly await the results of your survey.
- Unfortunately the studies to determine the effectiveness of lutein & zeaxanthin are very small samples and not of long duration like the Age Related Eye Disease Study (AREDS) was to show effectiveness of antioxidants and zinc/copper supplements. Doseage amounts and other factors are only determined for now on very weak study results and mostly set by supplement manufacturers. Therefore to recommend a supplement to a patient for the carotenoids is only done on a “we think it may be beneficial” basis. Quoting PDR for Nutritional Supplements “...show some promise of protecting against macular degeneration and may reduce the risk of cataract in some. Not exactly the confidence level one needs to prescribe these supplements with the assurance you can alter the course of a disease.
- Ask the questions: what information should be /or would you like to see/ on the pamphlets given out to your patients.
- Not aware of double blind studies like ARED study of ocuvite.
- Do you see studies have shown a solid relationship between lutein & zeaxanthin and see progression (not development) of macular degeneration?
- Unless I'm mistaken, it sounds like this study is being paid for by a pharmaceutical company.
- I think it is important to stress (1) A good diet with Fresh fruits and vegetables. (2) Moderate exercise (3) No smoking. Although supplements are good they give a false impression. A healthy Lifestyle will do more in most cases than taking high dose supplements.

- I am not aware of any studies conducted on these, other than those funded by pharmaceutical companies.
- Good luck on your study. My good friend did much of the original research on this subject at the University of Houston. He's a univ of \_\_\_\_\_ -- \_\_\_\_ grad circa 1971, career Army. Dr. Morris Lattimoie not sure of his result or where this info. may have been published. I saw parts in numerous journal studies in 1990's.
- I do not feel that the evidence for lutein and zeaxanthin, zinc, B-carotene, Vit E and Vit C are conclusive. The cause of age related macular degeneration of both the wet and dry forms are obscure and appear to have relationships to UV exposure, ethnicity (especially fair skin), nutrition, smoking and as yet unidentified factors. Having said this, a nutritional and/or supplemental approaches are relatively inexpensive, probably cause no harm and may be proven to help with macular degeneration. Therefore, I usually recommend the use of supplements, eg, OcuVite, to those patients presenting with drusen, macular pigmentary changes and early dry age related macular degeneration There also comes a time, eg, geographic atrophy, when nutritional approaches are too late.
- As optometrists counsel patients on the use of supplements, they must also inform patients of the cost of such products as OcuVite. A monthly supply is approximately \$20 ≡ \$240/yr which is a large amount for low income seniors. High intake of green leafy vegetables might be there only option...which is an excellent option overall.
- 1) Do you feel research has been convincing enough to state claims and specific regimens to a vulnerable subgroup of people yes, no, undecided (2) Do you feel research has been done and proven that you will not be doing peripheral damage to people in certain megadosing vitamin therapy. yes, no, undecided
- I don't understand the push for supplement with lutein and now there is a push for Preservision which doesn't contain Lutein. I don't understand why. I would like to have a copy of the results of your study.
- Basing current recommendations on National Eye Institute longitudinal study substantiating that approximately 25% of people with beginning macular degeneration can benefit from antioxidants and zinc supplements.
- There is too much confusion already amongst patients (especially the elderly) who are relying on info from different sources (MDs, ODs, RPhs/TV, Radio, Newsprint, Advertising, word-of-mouth, etc) Even OcuVite is in different formulations: The high dose AREDS formula vs a 100% USRDA & Lutein formulation. These people tend to believe almost anything they are told, but also most are on fixed incomes and cannot afford extensive & EXPENSIVE supplements that just are not necessary!!! \*Anyone concerned enough to ask, I recommend they take a regular multivitamin & eat their "green leafy veggies." The AREDS formula was of limited value & only to those with advanced AMD in one eye, but not the other yet, or moderate AMD – so those are the ones I recommend the higher dosing to – with important reservations [underlined three times]! Those who smoke (vs Quit Smoking!) or live with smokers → Zinc only – warnings on interactions of OTC meds, supplements, & Rx'd meds. – warnings on possibly depleting copper by taking high dose zinc/as well as the vitamin A/Beta C & Smoking risks. I also ALWAYS advise them to ALSO check with their regular physician in case he knows of any meds or complications that contraindicate these supplements that the patient neglected to inform me they have. Many elderly seem to already be trying folk medicines & supplements with varying sources and RISKS. They are being

TARGETS for SNAKE OIL & Mumbo Jumbo far too much for my liking – Sorry I got on my soap box!

- My nutritional counseling is limited to: (1) General nutritional info commonly accepted – eg eating a balanced diet perhaps weighted to fruits & veggies (2) AREDS study: specific supplements only for those diagnosed with non exudative AMD who want to do everything possible, that was produced by NEI study, to prevent conversion to exudative AMD & (3) Input from my very knowledgeable \_\_\_ologist (which can largely be state as #2 above!) i.e. don't educate on anything that hasn't been validated by good, large scale. Long term study by reputable investigators with limited monetary gain/interest.
- Of all the studies I have looked at, the AREDS study is probably the only good well controlled nutritional study looking at AMD and nutrition. This study did not look at lutein or zeaxanthin. Therefore, a lot of us in the eye care fields are recommending the nutritional supplements used in the AREDS study. Certainly there is growing evidence that other supplements such as lutein or zeaxanthin may work as well or better, but historical and population studies have way too many uncontrolled variables. Therefore, until we get better more controlled studies, Lutein and zeaxanthin become just one of the list of supplements along with many vitamins, minerals, and other antioxidants. Therefore, the questions regarding the recommendations of these compounds are yes they are and can be recommended but not exclusive of other supplements.
- Bilberry enhances circulation in the eye. WE always recommend bilberry be in a supplement or taken separately. CoQ10 is also useful in helping the eye to repair oxidative damage.
- Since finding lutein or zeaxanthin as a stand-alone product is very difficult, I would ask about this as apart of another supplement in addition to the current questions.