

AGE-RELATED EYE DISEASE AND THE COST EFFECTIVENESS OF USING LUTEIN AND ZEAXANTHIN



Prevalence and Social Consequences

Age-related macular degeneration (AMD) and cataracts are serious ophthalmic conditions that threaten the vision of a large percentage of the United States' elderly population and pose a significant financial burden. AMD and cataracts together are often referred to as Age-Related Eye Disease (ARED).

AMD affects the central part of the retina known as the macula (National Eye Institute, 2009). The macula is approximately 2 centimeters wide and is in the center of the retina. The two forms of AMD are wet and dry. Wet, or exudative, AMD occurs when irregular blood vessels begin to form underneath the macula (National Eye Institute, 2009). The blood vessels generally leak blood and fluid, raising the macula and distorting central, straightforward vision. Wet AMD is the most aggressive form of AMD, and visual impairment can occur in a short time. Wet AMD recently has attracted much scientific attention because of advances in therapeutic technology (National Eye Institute, 2009).

Dry AMD occurs when photoreceptors in the eye deteriorate and form fatty deposits (drusen) in the layer of cells underneath the retina (National Eye Institute, 2009). Dry AMD progresses slowly and generally affects the central vision over the course of many years. Many people who have AMD in only one eye may not experience any changes in visual acuity; however, if AMD affects both eyes, there will be a distortion in central vision, and more advanced cases will experience blurred gray spots in the straight-ahead vision field. AMD causes a blurred spot in central vision because it primarily affects the macula (National Eye Institute, 2009).

Dry AMD, which accounts for about 90% of diagnosed cases, is considered the early, and less severe, stage in the overall progression of the disease. (National Eye Institute, 2009) The more severe wet AMD accounts for the remaining 10% diagnosed cases and is responsible for the majority of AMD vision loss cases. Thus, those with the wet form have a greater prevention and therapeutic need. Therapies in development to halt the disease in its early stages may prevent the progression and catastrophic vision losses associated with the wet form.

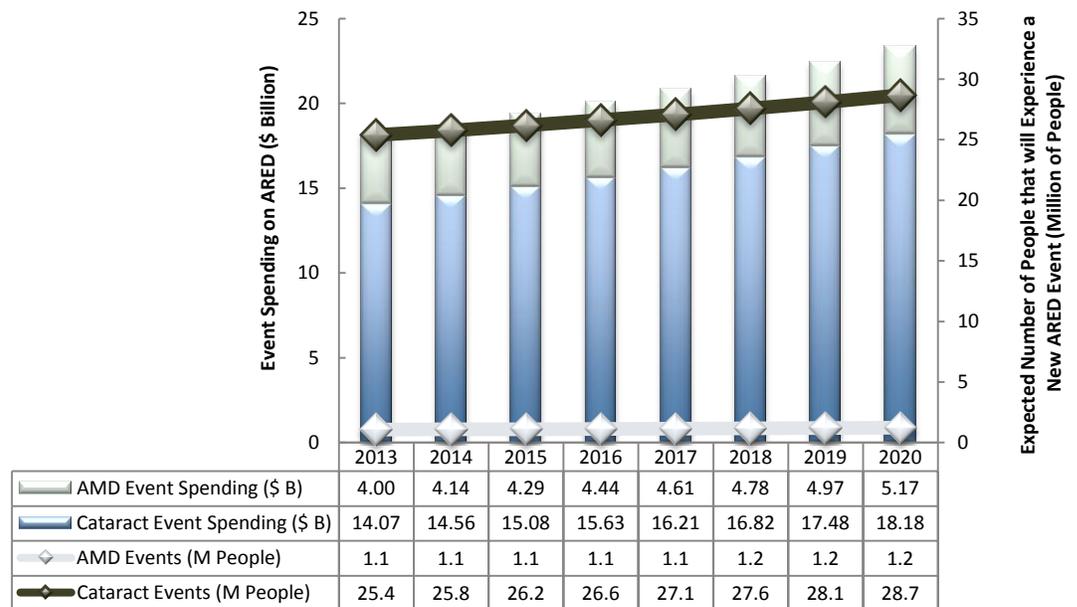
The total cumulative health care costs related to AMD and cataract events among all U.S. adults over the age of 55 diagnosed with ARED is expected to be over \$164 billion from 2013 to 2020.

Cataracts (clouding in the lens) are the result of the clumping together of proteins (National Eye Institute, 2009). As the cataract grows, visual acuity is decreased. Risk factors for developing cataracts are overexposure to ultraviolet light and radiation, as well as diabetes and hypertension.

In 2012, the total direct medical costs associated with AMD and cataracts, plus the related expected costs of post-procedure nursing care/assisted living services, was estimated at almost \$17.00 billion among all U.S. adults over the age of 55 (Agency for Healthcare Research and Quality—MEPS, Assisted Living Facilities.org, 2012, and Frost & Sullivan analysis). In the same year, an estimated 2.1 million people developed wet AMD, which can result in vision loss in as few as six months (Agency for Healthcare Research and Quality—MEPS). Furthermore, cataract prevalence in 2012 was 25.0 million Americans in the United States (Agency for Healthcare Research and Quality—MEPS). More than 3.7 million Americans over the age of 55 suffered from a cataract event and pursued surgery or other direct hospitalization services to treat the condition in 2012 (Agency for Healthcare Research and Quality—MEPS).

Cataracts and AMD can also limit independence and the ability to perform daily activities, which often results in additional indirect costs and significant emotional distress that affects quality of life. Specifically, an estimated 5% of all people over the age of 55 who suffer from an age-related eye disease (27.2 million people) will require post-procedure nursing care/assisted living services that averages about \$59,000 per year (Assisted Living Facilities.org, 2012).

Figure 6.1—Total Expenditure Forecast for Age-related Eye Disease-related Events among All U.S. Adults over the Age of 55, 2013–2020



Note: All figures are rounded. Source: Frost & Sullivan analysis.

Through 2020, an average of 4.8 million people over the age of 55 will experience a costly AMD or cataract event. This implies that the total cumulative health care costs related to ARED events among the target population will be more than \$164.40 billion—an average annual cost of nearly \$20.60 billion.

Multiple studies suggest that the use of lutein and zeaxanthin dietary supplements have a preventive effect on age-related eye disease. This will be explored in detail in this chapter.

Figure 6.2—Age-related Eye Disease Events Cost Summary for All U.S. Adults over the Age of 55, 2012 – 2020

| Metric | Measure |
|--|-----------|
| Population diagnosed with age-related eye disease, 2012 ²⁷ | 27.2 M |
| Expected number of adults over the age of 55 who will experience an age-related macular degeneration event, 2012 ²⁸ | 1.1 M |
| Expected number of adults over the age of 55 who will experience an age-related cataract event*, 2012 | 3.7 M |
| Event rate—percent of the high risk population that will experience an ARED event, 2012 (ER) | 33% |
| Total expenditures on age-related eye disease treatment procedures and post-procedure nursing care/assisted living services , 2012 | \$16.97 B |
| Average annual hospital utilization expenditures ARED events among all U.S. adults over the age of 55 with ARED forecast , 2013–2020 | \$20.55 B |
| Mean expenditures per person per year suffering from ARED, 2012 ²⁹ | \$3,535 |
| Expected mean expenditures per person per year suffering from ARED, 2013–2020 | \$4,431 |

Source: Summary Health Statistics for U.S. Adults: National Health Interview Survey 2011—Centers for Disease Control and Prevention, Center for Financing, Access and Cost Trends—Agency for Healthcare Research and Quality; Medical Expenditure Panel Survey, 2010, and Frost & Sullivan

The carotenoid pigments lutein and zeaxanthin are expected to play roles in protecting the eye from oxidative damage caused by light interacting with other pigments in the retina.

27 The total population of age-related eye disease sufferers includes all people diagnosed with age-related macular degeneration and/or cataracts.

28 An event is defined as any claimed treatment or disease management activity that requires expenditure to be paid out-of-pocket, by private insurance companies, or by Medicare or Medicaid and includes all hospital outpatient or office-based provider visits, hospital inpatient stays, and emergency room visits.

29 Mean expenditures per person per year suffering from age-related eye disease is defined as the sum of both expected direct medical costs per person experiencing an event per year (an average of \$243.57 per year) plus the expected costs of post-procedure nursing care/assisted living services (an average of \$59,262 per year for 5% of event sufferers, or an average of \$3,535.35 over the whole population of event sufferers).

Lutein and Zeaxanthin

Literature Review

Lutein and zeaxanthin are xanthophylls, a type of carotenoid pigment (Memorial Sloan-Kettering Cancer Center, 2013). They are found in high concentrations in the macula. Lutein and zeaxanthin are believed to play roles in protecting the eye from oxidative damage caused by light interacting with other pigments in the retina (Memorial Sloan-Kettering Cancer Center, 2013). Lutein and zeaxanthin are not synthesized by the body; major sources from dietary consumption include dark leafy vegetables such as spinach and kale, eggs, corn, and peppers (Memorial Sloan-Kettering Cancer Center, 2013).

In dry AMD, the concentration of pigments in the central part of the macula declines. Some studies have demonstrated that increasing dietary supplementation with lutein and/or zeaxanthin in AMD patients leads to an increase in macular pigment and improved visual acuity. Other studies, described below, link high dietary intake of lutein and zeaxanthin with decreased risk of AMD.

Lutein and zeaxanthin may also play a role in inhibiting the formation of cataracts. The protective effects of these pigments may prevent eye lens damage from ultraviolet light, which is believed to be a cause of cataracts. A few studies described below correlate high dietary intake of lutein and zeaxanthin with reduced incidence of cataracts.

In the United States, there is no government-recognized recommended daily intake level for lutein and zeaxanthin, but the American Optometric Association (AOA) suggests that 10 mg per day of lutein and 2 mg per day of zeaxanthin benefits eye health based on results of recent scientific studies. This is assumed to be sufficient to derive the expected benefits explored in this study (American Optometric Association, 2013). Carotenoids, including lutein and zeaxanthin, are discussed in the IOM volume on DRIs for antioxidant nutrients. However, no DRIs or UL have been established for carotenoids as a group or for any specific carotenoids (Institute of Medicine, 2000).

To deduce the expected efficacy of a treatment with lutein and zeaxanthin on the occurrence of an ARED event (AMD or cataract), a systematic search was conducted that focused on published studies that tested for and quantified the effect of their supplementation on ARED incidence requiring medical treatment and post-procedural care. The objective was to identify the best set of studies that tested for a direct causal relationship between intake of the dietary supplement and the relative risk of a disease event, and included studies similar in protocol in an attempt to control for observable variance. Studies were not selected on the basis of the magnitude, direction or statistical significance of the reported findings. A rigorous PubMed search identified more than 25 studies based on keyword combinations such as “lutein” and/or “zeaxanthin”; “macular degeneration” and/or “cataract”; and “risk reduction.” The search was conducted between February 1 and May 31, 2013.

Eleven studies including RCTs, prospective cohort studies, and cohort epidemiological studies were identified as being representative of the literature. Of the studies on AMD, one RCT and three case-controlled or cohort epidemiological studies were identified and selected for analysis. For cataracts, one RCT and six case-controlled or cohort epidemiological studies were selected. The studies are described below.

Figure 6.3—Lutein and Zeaxanthin Literature Review: Description of the Qualified Studies

| Author | Year | Event definition |
|---------------|------|--|
| Chew | 2013 | Progression to advanced AMD |
| SanGiovanni | 2007 | Neovascular AMD, geographic atrophy, or large or intermediate Drusen |
| Seddon | 2010 | Overall AMD (combined geographic atrophy and neovascular AMD) |
| Seddon | 1994 | AMD |
| Tan | 2008 | Neovascular AMD and geographic atrophy |
| Brown | 1999 | Cataract extraction in men |
| Chasan-Taber | 1999 | Cataract extraction in women |
| Chew (AREDS2) | 2013 | Progression to cataract surgery |
| Christen | 2008 | Incidence of cataracts in women |
| Jacques | 2001 | Prevalence of nuclear opacities in non-diabetic women |
| Vu | 2006 | Prevalence of nuclear cataract |

Note: All figures are rounded. Source: Frost & Sullivan

Seddon et al., (1994) conducted a case-controlled study that matched 356 people in the U.S. with advanced AMD with a control group of 520 persons with other eye diseases (Seddon, et al., 1994). The relative risk of AMD was estimated according to various indicators, including dietary components. In comparing the highest and lowest quintiles of lutein and zeaxanthin intake, the authors found a statistically significant reduction in the risk of AMD (odds ratio 0.57, 95% CI 0.35 to 0.92). SanGiovanni et al., (2007) conducted another case-controlled study of 4,519 subjects in the U.S., most of whom had some degree of AMD (SanGiovanni, et al., 2007). Data on dietary intake were analyzed and tested versus AMD incidence. A statistically significant reduction in neovascular AMD incidence (odds ratio 0.65; 95% CI 0.45 to 0.93) was identified in comparing the highest and lowest quintiles of lutein and zeaxanthin intake. Tan et al., (2008) conducted a population-controlled cohort study of diet and AMD incidence in 3,654 participants in Australia (Tan, Wang, Flood, Rochtchina, Smith, & Mitchell, 2008). Participants in the highest tertile of dietary lutein and zeaxanthin intake had a relative risk for incident AMD of 0.35 (95% CI 0.13 to 0.92). Seddon et al., (2010) compared 545 subjects with AMD to 275 subjects without AMD in a case-controlled study (Seddon, Reynolds, & Rosner, 2010). In comparing the highest and lowest tertile of lutein intake, the odds ratio for overall risk of AMD was 0.6 (95% CI 0.4 to 1.0).

Another study included in this analysis is Age-Related Eye Disease Study II (AREDS2), a randomized, controlled trial testing dietary supplements in 4,203 subjects at risk for progression to advanced AMD (Chew et al., 2013). All participants took a daily formulation of vitamins C and E, beta carotene, zinc, and copper, which in an earlier AREDS randomized controlled study (Age-Related Eye Disease Study Research Group, 2001) was shown to reduce the risk of developing advanced AMD. In AREDS2, a group of participants additionally took a daily supplement of lutein (10 mg) and zeaxanthin (2 mg). Eye examinations were conducted over a median of 5 years to assess progression to advanced AMD. The primary analysis compared subjects supplemented with the AREDS formulation and lutein plus zeaxanthin to those supplemented with AREDS formulation only. The hazard ratio for progression to advanced AMD was 0.90 for the lutein plus zeaxanthin group (98.7% CI 0.76 to 1.07). This is the value Frost & Sullivan used in the analysis of risk reduction, combined with the above-mentioned observational studies (Figure 6.4). However subgroup and secondary analyses in AREDS2 suggest that lutein plus zeaxanthin supplementation may result in even lower hazard ratios for AMD. For example, the hazard ratio was 0.74 (98.7% CI 0.59 to 0.94) for progression to advanced AMD in participants with the lowest quintile of dietary lutein and zeaxanthin intake. Also, for a subgroup that received lutein plus zeaxanthin and a variant of the AREDS formulation that lacked beta carotene, a hazard ratio of 0.82 (95% CI 0.69 to 0.96) for progression to advanced AMD was found. Only the primary result was used for the present analysis, rather than subgroup and secondary results of Chew et al., to maintain consistency with analyses of other supplements in the present study.

Studies linking dietary consumption of lutein and/or zeaxanthin to primary prevention of cataracts were also identified. One randomized controlled trial and six prospective cohort or epidemiological studies were identified and selected for analysis, as described below.

In a prospective cohort study, Brown et al., (1999) followed the dietary intake of 36,644 male health care professionals in the United States for 8 years and quantified the incidence of cataract extractions (Brown, et al., 1999). When comparing the highest and lowest quintiles of lutein and zeaxanthin intake, the risk of cataract extraction was 19% lower (95% CI 0.65 to 1.01) in the high-intake group. Chasan-Taber et al., (1999) prospectively examined the association between lutein and zeaxanthin intake and the incidence of cataract extractions among 77,466 U.S. women over a period of 12 years (Chasan-Taber, et al., 1999). Comparing subjects in the highest quintile with those in the lowest quintile of lutein and zeaxanthin intake, the relative risk of cataract extraction was 0.88 (95% CI 0.75 to 1.03). Jacques et al., (2001) conducted a prospective cohort study of 478 non-diabetic U.S. women over 13 to 15 years (Jacques, et al., 2001). Nutrient intake was evaluated and tested against the incidence of cataracts, measured as nuclear lens opacities. The prevalence of cataracts was significantly lower in the highest quintile of lutein/zeaxanthin intake than in the lowest quintile, with an odds ratio of 0.52 (95% CI 0.29 to 0.91). Vu et al., (2006) studied nuclear cataract prevalence in 1,955 people in Australia (Vu, Robman, Hodge, McCarty, & Taylor, 2006). For those in the top quintile of lutein and zeaxanthin intake the odds ratio for nuclear cataracts was 0.58 (95% CI 0.37 to 0.92). Christen et al., (2008) prospectively studied more than 35,000 U.S. women over 10 years, evaluating nutrient intake and self-reported cataract incidence (Christen, Liu, Glynn, Gaziano, & Buring, 2008). The relative risk of cataracts in the highest quintile of lutein/zeaxanthin intake was 0.82 (95% CI 0.71 to 0.95) compared with the lowest quintile.

The AREDS2 clinical trial also is included in this analysis in the context of cataracts. Chew et al., followed the 4,203 AREDS2 subjects for a median 4.7 years to document cataract surgeries (Chew et al, 2013). That analysis compared subjects supplemented with lutein plus zeaxanthin to those who did not receive these ingredients. The hazard ratio for cataract surgery was 0.96 for the lutein plus zeaxanthin group (98.7% CI 0.84 to 1.10). Frost & Sullivan used this study value in its analysis of risk reduction, combining results from the above-mentioned observational studies of cataracts (Figure 6.5).

Figure 6.4—Lutein and Zeaxanthin Literature Review: Description of the Qualified Studies—Summary of Findings, Age-related Macular Degeneration

| Author | Total sample (N) | AMD relative risk (RR) for lutein and zeaxanthin, hazard ratio or top versus bottom quantile | Study weights based on sample size variance |
|-------------------------|------------------|--|---|
| Chew (AREDS2) | 4,203 | 0.90** | 43.3% |
| SanGiovanni | 1,772 | 0.65* | 18.3% |
| Seddon | 820 | 0.60* | 8.4% |
| Seddon | 876 | 0.57* | 9.0% |
| Tan | 2,035 | 0.77*** | 21.0% |
| Estimated relative risk | | 77.0% | |

* Odds ratio, top versus bottom quintile
 ** Hazard ratio compared to no treatment
 *** Relative risk, top versus bottom tertile

Note: All figures are rounded. Source: Frost & Sullivan

An average of 14,406 AMD events per year and an average of 957,318 cataract events per year could potentially be avoided if all U.S. adults over the age of 55 diagnosed with ARED were to use lutein and zeaxanthin dietary supplements at protective levels during the forecast period.

Figure 6.5—Lutein and Zeaxanthin Literature Review: Description of the Qualified Studies—Summary of Findings, Age-related Cataracts

| Author | Total sample (N) | Cataracts relative risk (RR) for lutein and zeaxanthin, hazard ratio or top versus bottom quintile | Study weights based on sample size variance |
|-------------------------|------------------|--|---|
| Christen | 35,551 | 0.82 | 22.7% |
| Jacques | 478 | 0.52* | 0.3% |
| Brown | 36,640 | 0.81 | 23.4% |
| Chasan-Taber | 77,466 | 0.88 | 49.6% |
| Vu | 1,955 | 0.58* | 1.3% |
| Chew (AREDS2) | 4,203 | 0.96** | 2.7% |
| Estimated relative risk | | 0.85 | |

* Odds ratio

** Hazard ratio compared to no treatment

Note: All figures are rounded. Source: Frost & Sullivan

Empirical Results

Based on the results of the literature review, it was determined that 95 people would need to be treated with lutein and zeaxanthin to avoid one age-related macular degeneration event, and 23 people would need to be treated with lutein and zeaxanthin to avoid one cataract event. Both of these NNT estimates were calculated using the CEBM approach.

Given the NNT for AMD of 159 people, if every person over the age of 55 with ARED were to take lutein and zeaxanthin supplements at the preventive daily intake levels, avoided expenditures related to AMD would average \$57.4 million per year—a cumulative savings of \$458.8 million from 2013 to 2020. This savings is based on an average expenditure per person experiencing an ARED event of \$4,431, which includes direct medical costs and post-procedure assisted living costs. This equates to an annual average of 14,406 avoided AMD events from 2013 to 2020—115,248 cumulative AMD avoided events.

Regarding the NNT for cataracts of 28 people, the effect on avoided direct medical costs and post-procedure assisted living costs related to cataracts given the daily use of lutein and zeaxanthin supplements at preventive levels would average \$3.8 billion per year, for a cumulative savings of \$30.5 billion from 2013 to 2020. This is associated with an annual average of 957,318 avoided cataract events from 2013 to 2020—7,658,543 cumulative avoided events. See Figures 8.21 to 8.25 in the appendix for a detailed reporting of the empirical results.

Figure 6.6—Lutein and Zeaxanthin Literature Review: Overall Results—CEBM Approach

| Metric | Measure |
|---|-----------|
| Expected event rate of AMD among the target population* (ER _{AMD}) | 2.8% |
| Expected event rate of cataracts among the target population* (ER _{CATARACTS}) | 33.0% |
| Weighted AMD event relative risk (weighted for sample size variance) (RR _{AMD}) | 77.0% |
| Weighted Cataracts event relative risk (weighted for sample size variance) (RR _{CATARACTS}) | 84.7% |
| Estimated number of people needed to be treated to avoid one age-related macular degeneration event (NNT _{AMD}) | 159 |
| Estimated number of people needed to be treated to avoid one cataract event (NNT _{CATARACTS}) | 28 |
| Cumulative number of avoided age-related macular disease events, 2013–2020 | 115,248 |
| Cumulative number of avoided cataract events, 2013–2020 | 7,658,543 |

* Among all U.S. adults over the age of 55 with ARED
 Note: All figures are rounded. Source: Frost & Sullivan

Based on the review of best-selling products in leading brick-and-mortar, online, and mail-order retail establishments, the price of a daily dose of lutein and zeaxanthin, ranges from as low as \$0.11 to as high as \$0.57 for 1 daily dose. The median price per daily dose is \$0.29.

Thus, the annual expected cost of lutein and zeaxanthin dietary supplementation for all U.S. adults over the age of 55 with AMD or cataracts would be \$106.50 per person—more than \$2.9 billion per year for the total sub-population, and more than \$23.2 billion cumulatively from 2013 to 2020.

Figure 6.7—Lutein and Zeaxanthin Cost Analysis: Summary Results—Cost of Dietary Supplementation of the Target Population, 2013–2020

| Metric | Measure |
|---|-----------|
| Median per person cost of lutein and zeaxanthin supplementation at protective intake levels, 2013 | \$0.29 |
| Expected per person annual median cost of lutein and zeaxanthin supplementation at protective intake levels, 2013 | \$106.50 |
| Average annual cost of lutein and zeaxanthin dietary supplementation of the target population*, 2013–2020 | \$2.90 B |
| Cumulative cost of lutein and zeaxanthin dietary supplementation of the target population*, 2013–2020 | \$23.22 B |

* Among all U.S. adults over the age of 55 with ARED
 Note: All figures are rounded. Source: Frost & Sullivan

An average of \$3.87 billion per year and a cumulative savings of \$30.95 billion from 2013 to 2020 in avoidable health care utilization costs is potentially realizable if all U.S. adults over the age of 55 diagnosed with AMD or cataract were to use lutein and zeaxanthin dietary supplements at protective levels

Over \$7 billion in cumulative net ARED-attributed health care cost savings from 2013 to 2020 is potentially realizable if the entire target population were to use lutein and zeaxanthin dietary supplements at protective intake levels.

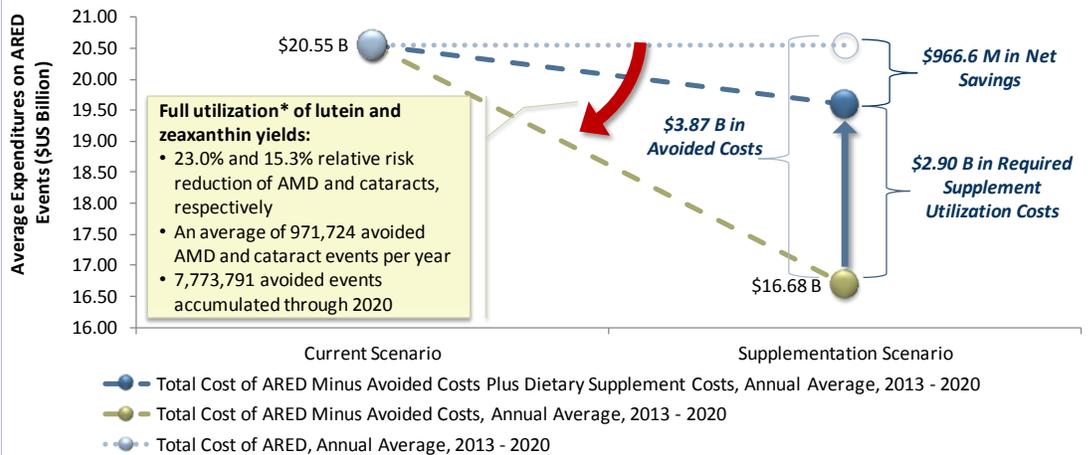
Figure 6.8—Lutein and Zeaxanthin Cost Analysis: Summary Results—Avoided Health Care Expenditures* due to Dietary Supplement Intervention, 2013–2020

| Metric | Measure |
|---|------------|
| Average annual avoided expenditures related to ARED as a result of lutein and zeaxanthin supplement intervention, 2013–2020 | \$3.87 B |
| Cumulative avoided expenditures related to ARED as a result of lutein and zeaxanthin supplement intervention, 2013–2020 | \$30.95 B |
| Average annual total expenditures on ARED-related events among the target population* if incidence of events is reduced through the use of lutein and zeaxanthin supplements, 2013–2020 | \$16.68 B |
| Cumulative total expenditures on ARED-related events among the target population* if incidence of events is reduced through the use of lutein and zeaxanthin supplements, 2013–2020 | \$133.48 B |

* Among all U.S. adults over the age of 55 with ARED
 Note: All figures are rounded. Source: Frost & Sullivan

Knowing that the total cost savings derived from avoided ARED events for the same population was, on average, \$3.9 billion per year and nearly \$31.0 billion cumulatively from 2013 to 2020, the net savings, after accounting for the cost of lutein and zeaxanthin dietary supplementation, would average \$966.6 million per year and would be more than \$7.7 billion cumulatively from 2013 to 2020.

Figure 6.9—Lutein and Zeaxanthin Cost Analysis: Net Health Care Cost Savings* Summary Results, 2013–2020



* Among all U.S. adults over the age of 55 with AMD or cataract
 Note: All figures are rounded. Source: Frost & Sullivan

Figure 6.10—Lutein and Zeaxanthin Cost Analysis: Summary Results—Net Cost Savings* due to Avoided Health Care Expenditures through Dietary Supplement Intervention, 2013–2020

| Metric | Measure |
|---|-----------|
| Average net potential direct savings per year from avoided ARED-related events among the target population* due to lutein and zeaxanthin supplement intervention, 2013–2020 | \$966.6 M |
| Cumulative net potential direct savings from avoided ARED-related events among the target population* due to lutein and zeaxanthin supplement intervention, 2013–2020 | \$7.73 B |
| Net benefit cost ratio, \$ per one dollar spent on dietary supplement | \$1.33 |

* Among all U.S. adults over the age of 55 with AMD or cataract.

Note: All figures are rounded. Source: Frost & Sullivan

The subsequent cost-benefit analysis assumes that in the supplementation scenario all people over the age of 55 with AMD or cataract use lutein and zeaxanthin dietary supplements at preventive daily intake levels from a base of zero usage among this population segment. In other words, the calculated net savings is actually the total potential net savings that are realizable. However, because a significant number of adults over the age of 55 are regular users of lutein and zeaxanthin dietary supplements, this segment of the target population already has a reduced risk of experiencing a costly ARED event and is already realizing the supplements’ risk-reducing benefits.

According to the 2012 Council for Responsible Nutrition Consumer Survey on Dietary Supplements conducted by Ipsos Public Affairs, 4% of U.S. adults over the age of 55 are regular users of lutein dietary supplements (Ipsos Public Affairs, 2012)³⁰. Because of the fact that the majority of lutein dietary supplement products in the market are often paired with zeaxanthin due to its near identical chemical composition and both nutrients are found to occur together in nature, it is also expected that zeaxanthin usage levels are similar in scale. This implies that 96% do not realize the potential benefits from regular use. Because avoided expenditures and net cost savings are a direct function of the total number of people in the target population using these supplements, the calculation of avoided health care expenditures and net cost savings yet to be realized is simply a proportional adjustment of the total potential avoided expenditures and net cost savings.

It is expected that there are significant potential ARED-attributed cost savings yet to be realized valued at an annual average of nearly \$1 billion per year if the use of lutein and zeaxanthin dietary supplements among current non-regular users in the high-risk target population were to increase their use to protective levels of intake.

³⁰ It is not known what percentage of this target population segment also suffers from ARED events, but for the purposes of this analysis, Frost & Sullivan has made the assumption that approximately the same percentage (4%) of adults over the age of 55 with ARED are also regular users of lutein (and presumably zeaxanthin as well due to both nutrients close association). Also for the purposes of this analysis, as the Ipsos survey did not ask dosage, Frost & Sullivan has made the assumption that regular users in this target population are highly likely to be consuming enough lutein and zeaxanthin to provide a protective effect. More research is required to test these assumptions.

In addition to the direct health care costs attributed to AMD and cataracts, the intangible costs, such as the significant physical and emotional distress of ARED sufferers and their families are also additional burdens to consider in assessing the overall quality of life and consequently the total social cost of AMD and cataracts.

Knowing this, it is expected that \$39.8 million of the \$966.6 million net potential direct savings per year from avoided ARED events because of lutein and zeaxanthin dietary supplement intervention is already realized in the total expected ARED costs. This equates to an average of 932,855 avoidable events per year yet to be realized, and an average of \$927.9 million per year in net savings yet to be realized—nearly \$7.42 billion in cumulative net savings from 2013 to 2020. Thus, it is expected that there are significant cost savings yet to be realized through the increased usage of lutein and zeaxanthin dietary supplements among the high-risk target population.

Figure 6.11—Lutein and Zeaxanthin Cost Analysis: Summary Results—Net Cost Savings* Yet to be Realized due to Avoided Health Care Expenditures through Dietary Supplement Intervention, 2013–2020

| Metric | Measure |
|--|-----------|
| Percentage of the target population* who are regular users of lutein and zeaxanthin dietary supplements, 2012 | 4% |
| Average number of events avoided annually among the target population* yet to regularly use lutein and zeaxanthin, 2013–2020 | 932,855 |
| Cumulative number of events avoided among the target population* yet to regularly use lutein and zeaxanthin, 2013–2020 | 7,462,840 |
| Average net direct savings per year from avoided ARED-related events due to lutein and zeaxanthin dietary supplement intervention yet to be realized, 2013–2020 | \$927.9 M |
| Cumulative net direct savings per year from avoided ARED-related events due to lutein and zeaxanthin dietary supplement intervention yet to be realized, 2013–2020 | \$7.42 B |

* Among all U.S. adults over the age of 55 with AMD or cataract.

Source: Note: All figures are rounded. Source: Ipsos Public Affairs and Frost & Sullivan

Conclusion

The estimated total expenditures on the direct medical costs associated with ARED events plus the related expected costs of nursing care/assisted living services because of reduced vision was almost \$17.00 billion in 2012. Based on the findings of this report, the use of lutein and zeaxanthin dietary supplements could result in a savings of nearly \$1.00 billion per year—more than \$7.70 billion from 2013 to 2020. In other words, \$1.33 in avoided costs can be saved per \$1 spent on lutein and zeaxanthin supplements.

The key source of these potential costs is tied to expected post-ARED-event reduced vision, which results in an overall lower quality of life. Specifically, cataracts and AMD can limit a person's independence and ability to perform daily activities. In addition, intangible costs not captured in the analysis, such as significant physical and emotional distress of ARED sufferers, are additional burdens to consider in assessing overall quality of life. It is estimated that 5% of all people over the age of 55 who suffer from an ARED event will require costly post-ARED event nursing care/assisted living services that cost about \$59,000 per year. These costs likely will fall on relatives or the government in the form of Medicare. Therefore, any means to help reduce these costs, including the adoption of key eye-health supplements that are shown to have a substantial health benefit, should be considered as a viable tool to reduce the burden of this disease and related financial costs.

