Vitamin D insufficiency has been found to be as high as 75% among community-dwelling adults aged 65 and older (Hintzpeter, Mensink, Thierfelder, & Scheidt-Nave, 2007). People aged 70 and older have about 25% less capacity for vitamin D production compared to younger adults (Holick, Matsuoka, & Wortsman, 1989). Insufficient vitamin D levels may have considerable effect on cancer-related diagnosis and treatment (Beer & Myrthue, 2006; Grant & Garland, 2006; Pelczynska et al., 2006; Sieg, Sieg, Dreyhaupt, & Schmidt-Gayk, 2006). Vitamin D also has been found to reduce the risk of premenopausal breast cancer (Abbas, Linseisen, & Chang-Claude, 2007) and has been associated with a decrease in total mortality in the general population (Autier & Gandini, 2007). Other benefits of vitamin D include reduced falls, reduced injury from falls, and enhanced functional status. This research synthesis will consider the issue of vitamin D as related to normative aging, cancer diagnoses, treatment, functional status, and falls in older patients with cancer.

**Definition of Vitamin D**

According to the National Institutes of Health (NIH, 2005), vitamin D is a fat-soluble substance that is derived from exposure to sunlight. Vitamin D frequently is identified as a vitamin; however, some researchers suggest it is a hormone because manufacturing takes place through sun exposure (Mosekilde, 2005; Wootton, 2005). Several different forms of vitamin D exist, including cholecalciferol (D3) (NIH) and ergocalciferol (D2). Cholecalciferol is made in the skin of animals and people (Holick, 2005). Vitamin D is manufactured in the skin after sunlight exposure; cholecalciferol binds to the vitamin D binding protein and is transported to the liver where it is hydroxylated into 25-hydroxy vitamin D (25 OH-D) (Wootton) (see Figure 1). The 25 OH-D then travels to the kidney where it is hydroxylated to 1,25 OH2D (Mosekilde). Ergocalciferol is a plant form of vitamin D (Holick) that goes through the same hydroxylation as cholecalciferol (Wootton); 25 OH-D often is referred to as calcidiol and 1,25 OH2D is known as calcitriol (Boonen, Vanderschueren, Haentjens, & Lips, 2006; Wootton). When comparing supplementation with calciferol (D2) or calcitriol (D3), calciferol was shown to be less potent and have a shorter duration of action when compared to calcitriol (Armas, Hollis, & Heaney, 2004).

Vitamin D generally is obtained in the diet by consuming fish, fish oils, and egg whites. D2 and D3 generally are used as supplementation in milk, bread, and multivitamins (Holick, 2005). The daily requirement of vitamin D is 600 IU (American Dietetic Association [ADA], 2006). However, higher doses of D3 seem to be necessary to reach the desirable health benefits...
of preserving bone density and reducing falls and injuries from falls in healthy adults (Vieth, 2004). For people aged 65 and older, some evidence suggests that dosages of D₃ should amount to an additional 2,600 IU per day of oral supplementation to have sufficient 25 OHD levels (Heaney, 2006; Vieth, Ladak, & Walfish, 2003). The predominant role of vitamin D in the body is the promotion of bone health.

**Signs and Symptoms of Vitamin D Insufficiency and Toxicity**

Many physiologic changes occur during aging which may be linked to vitamin D deficiency, such as low serum calcium and hyperparathyroidism accompanied with bone reabsorption and osteopenia (Passeri et al., 2003). Fractures and reduced bone mineralization also are signs of vitamin D deficiency (Need, 2006; Wong & Anpalahan, 2006). Ricketts can occur in adults, resulting in skeletal deformities and low serum calcium levels. More nonspecific symptoms can be present, such as weakness, misdiagnosed fibromyalgia, and pain (Lyman, 2005). Older adults with chronic disease who are homebound and malnourished should be considered at particular risk for vitamin D deficiency (Richardson, 2005).

Signs and symptoms of vitamin D toxicity generally are rare but should be addressed in the healthcare plan. Vitamin D toxicity has occurred in patients receiving 100,000 IU per day over a period of months. Serum calcium levels are generally evaluated when vitamin D toxic symptoms occur (Beers & Berkow, 2005). Symptoms of vitamin D toxicity are anorexia, nausea and vomiting, polyuria, polydipsia, weakness, nervousness, and pruritus. Serum 25 OHD and 1,25 OH₂D levels might not be elevated in tandem in cases of vitamin D toxicity. Serum 25 OHD levels may be as high as 15 times the recommended serum parameters; however, 1,25 OH₂D levels may remain within normal limits (Beers & Berkow).

Although weakness and anxiety may be symptoms of vitamin D toxicity, they also can be associated with cancer treatment. Fatigue and weakness are common in patients with cancer, and fatigue was rated as one of the five most common causes of distress in patients with cancer (Loscalzo & Clark, 2007). Nausea, vomiting, and anorexia also are common in patients undergoing chemotherapy and would be difficult to distinguish from vitamin D toxicity or hypercalcemia without checking serum 25 OHD toxicity or hypercalcemia without checking serum 25 OHD levels and calcium levels.

**Cancer and Vitamin D**

Vitamin D insufficiency has been associated with increased risk for some cancer diagnoses, particularly gastrointestinal cancers (Giovannucci et al., 2006). Vitamin D insufficiency may actually play a role in the carcinogenesis of colorectal cancers (Sieg et al., 2006). Researchers believe that sufficient vitamin D levels may reduce the risk of developing some forms of cancer; however, more research is needed to understand the role of vitamin D and cancer.

Vitamin D used alone or with anticancer agents may have a role in cancer treatment. Beer and Myrthue (2006) found some promising results from a preliminary study of calcitrol combined with antineoplastic agents that may lead to additional clinical trials for prostate cancer treatment. A preliminary evaluation of vitamin D and benign prostatic hyperplasia by Maggi, Crescioli, Morelli, Collì, and Adorini (2006) found reduced prostatic growth and anti-inflammatory effects, which warrant further research and continued development in clinical trials. Treating colon cancer to sensitize cancer cells and inhibit cell growth may be more effective than using vitamin D alone or in conjunction with other chemotherapeutic agents (Koren, Wacksberg, Weitsman, & Ravid, 2006). Vitamin D also has been found to have an effect on breast cancer in sensitizing the cells to react to other chemotherapy agents (Weitsman et al., 2005). A similar finding was produced by Flanagan et al. (2005) in estrogen-positive breast cancer tumors with vitamin D₃ acting synergistically with other anticancer agents or alone.

Patients with cancer who are aged 69 and older may be at even greater risk for vitamin D insufficiency and potential adverse effects, such as bone loss. Cancer treatment-related bone loss is more common in patients with breast and prostate cancer who are undergoing hormonal therapy or chemotherapy (Michaud & Goodin, 2006). Various cancer therapies, bone metabolism, reduced vitamin D, and insufficient calcium intake also can contribute to bone loss. Chemotherapeutic agents that may enhance bone loss are methotrexate, cyclophosphamide, ifosfamide, and doxorubicin (Michaud & Goodin; Pfleischnfiter & Diel, 2000). Aromatase inhibitors also can induce treatment-related bone loss (Gnant, 2006; Miney et al., 2006).

Cancer survival rates have been associated with natural vitamin D levels from sun exposure (Grant, 2006). According to Krause, Matulla-Nolte, Essers, Brown, and Hopfenmuller (2006), health benefits of natural vitamin D may outweigh the risk of skin cancer, but the optimum amount of exposure must still be considered. Patients must moderate the time spent in the sun to balance the risk associated with squamous cell carcinoma and melanoma (Krause et al.). Sun exposure, including solar ultraviolet irradiance, was found to diminish cancer mortality rates despite the risk from skin cancer (Grant & Garland, 2006). Sun exposure alone without vitamin D and calcium supplementation does not lead to sufficient 25 OHD levels (van der Wielen et al., 1995).
High levels of vitamin D at the time of diagnosis and during treatment for cancer may improve health outcomes for many tumor types (Robsahm, Tretli, Dahlback, & Moan, 2004). Exposure to sunlight over time helps produce metabolites that can play a role in cancer survival (Cui & Rohan, 2006). Patients diagnosed in summer and autumn had improved survival when compared to those diagnosed in winter (Lim et al., 2006). Sunlight exposure also reduces the risk of non-Hodgkin lymphoma (Hughes et al., 2004).

**Aging and Vitamin D**

Aging tends to be a risk factor for vitamin D insufficiency. Skin becomes less efficient in manufacturing vitamin D. Intestinal absorption of vitamin D is less productive in older adults, which contributes to lower levels of 25 OHD (Pattanaungkul et al., 2000). In addition, people who have increased body fat have been shown to have less bioavailability of vitamin D when compared to people with less body mass (Wortman, Matsuoka, Chen, Lu, & Holick, 2000). For older adults living in developed countries, vitamin D levels are likely to be low because of reduced exposure to sunlight and inadequate diet (van der Wielen et al., 1995). Many older adults living in subtropical climates have low vitamin D levels (25 OHD) even in the summer (Lucas et al., 2005), which supports the belief that ample sunlight exposure is necessary but often not sufficient to provide adequate vitamin D levels.

Low vitamin D levels are a risk factor for falls and poor functional status (Gerdhem, Ringsberg, Obrant, & Akesson, 2005; Pluim et al., 2006). Insufficient vitamin D levels have a relationship to increased risk for falls in older adults living in nursing homes (Stein et al., 1999), in a community dwelling (Dukas, Staehelin, Schacht, & Bischoff, 2005), in the inner city (Dharmarajan, Akula, Kuppachi, & Norkus, 2005), and in the general community (Gerdhem et al.; Larsen, Mosekilde, & Foldspang, 2004; Sambrook et al., 2004). In a descriptive study of older patients at an outpatient fall clinic, 72% had low vitamin D levels and 31% were classified as having severely low levels (Dhesi, Moniz, Close, Jackson, & Allain, 2002). Vitamin D levels below 25 ng/mg of 25 OHD had an increased risk of fracture resulting from a fall (Gerdhem et al.). Insufficient vitamin D status is independently associated with enhanced risk of falls for older patients aged 65–75 (Snijder et al., 2006).

Low vitamin D levels have been associated with reduced functional status, falls, and injury from falls in older adults (Dukas et al., 2005; Gerdhem et al., 2005; Stein et al., 1999). Overcash (2007b) found that 21% of patients aged 70 and older diagnosed with cancer reported a fall. Older patients who were able to double their vitamin D levels experienced a 20% reduction in risk of falls (Flicker et al., 2003).

Calcium is an essential component to vitamin D in that it aids in intestinal absorption (Lips, 2006). Calcium supplementation helps accentuate bone health (Boonen, Bischoff-Ferrari, et al., 2006). When calcium levels are low, the stimulation of parathyroid levels promote bone reabsorption, causing an increased risk for fractures (Boonen, Vanderschueren, et al., 2006). Older patients with cancer who are considered frail may be a target for calcium and vitamin D supplementation (Boonen, Vanderschueren, et al.).

**Measurement of Vitamin D**

Vitamin D frequently is measured as a serum 25 OHD or calcidiol (Al-oanzi et al., 2006). Many studies use serum 25 OHD levels to determine vitamin D insufficiency; however, variations do exist between brands and types of serum assays (Binkley et al., 2004). Methods of determining 25 OHD are Nichols Advantage CPBA, DiaSorin RIA and LIAISON assays, and HPLC. HPLC has been found to be the most reliable when compared to other serum 25 OHD assays (Lenschmeyer, Wiebe, Binkley, & Drezer, 2006). DiaSorin RIA and LIAISON 25 OHD levels were found to be about equal in determining vitamin D insufficiency (Souberbielle et al., 2005). The accuracy of vitamin D measurement must contain clear guidelines to interpreting the laboratory values so prudent clinical decisions can be made (Morris, 2005). Vitamin D deficiency is defined as below 20–32 ng/ml and vitamin D sufficiency is considered in the range of 33–80 ng/ml (assay use not reported) (Grant & Holick, 2005; Mosekilde, 2005). Mean 25 OHD levels have been found to be lower in women (23 nmol/l) compared to men (39 nmol/l) (Bolland et al., 2007).

**Role of Vitamin D in Functional Status and Falls in Older Patients With Cancer**

Functional status is an important element to the quality of life of an older patient with cancer (Goodwin, Hunt, & Samet, 1993; Overcash, Beckstead, Extermann, & Cobb, 2005). Functional status limitations are common in older patients with cancer (Flood et al., 2006). In a study by Goodwin et al., functional status of older patients was found to impact determinants of cancer therapy by oncologists. Falls are a key component in the issue of functional status and should be assessed in all older patients with cancer (Extermann, Overcash, Lyman, Parr, & Balducci, 1998).

Vitamin D supplementation, along with calcium, has been found to be beneficial in older community-dwelling adults. A study comparing alfalcaldiol (1 mcg) (a calcium supplement) to placebo in independent older adults found that those receiving alfalcaldiol and a calcium intake of 523 mg per day had fewer falls (Dukas et al., 2004). Moreover, vitamin D supplementation at 400 IU plus calcium at 800 mg per day showed improved muscle strength, improved gait speed, and reduced body sway in a patient population aged 70 and older who were not considered frail (Bunout et al., 2006).

Many older community-dwelling adults are living with a cancer diagnosis. Cancer treatment with chemotherapy often is administered in the outpatient setting and the care plan should incorporate interventions for fall reduction, such as vitamin D supplementation.

Men and women have differing responses to vitamin D supplementation. Men have less vitamin D insufficiency compared to women, even in the winter months (Bolland et al., 2006). However, men may be less receptive to vitamin D treatment effects. A three-year study by Bischoff-Ferrari, Orav, and Dawson-Hughes (2006) investigated older community-dwelling adults and found that cholecalciferol plus calcium reduced the chance of falling by 46% in more active women and 65% in less active women.
active women. A neutral effect was recorded in more active and less active men.

**Nursing Interventions to Enhance Vitamin D in Older Patients With Cancer**

The first step in addressing vitamin D insufficiency is to assess if the patient is currently taking supplementation. Many primary care providers have established a vitamin D and calcium regime in older patients who also are treated by an oncologist. Asking the patient to bring the vitamin containers for evaluation if they are presenting for an ambulatory care visit may be helpful.

The ADA (2006) has recommended a combination of 600 mg per day of vitamin D and 1,200 mg per day of calcium; however, some studies suggest that older patients with cancer may require higher doses of vitamin D (700–800 mg per day). Others recommend higher doses depending on the intended outcome. Intramuscular injection of 600,000 IU of ergocalciferol without calcium administration did not reduce falls but did enhance functional performance, balance, and reaction time (Dhesi et al., 2004). A meta-analysis found that vitamin D supplementation of 700–800 IU per day appeared to reduce the risk of falls in 12 randomized controlled trials. However, 400 IU per day of vitamin D is insufficient for fracture prevention as a result of falls (Bischoff-Ferrari et al., 2004). A three-year intervention study by Larsen et al. (2004) focused on 9,605 older community-dwelling adults found that 400 IU of vitamin D and 1,000 mg of calcium daily led to a 12% reduction in falls requiring acute hospitalization. A single oral dose of 100,000 IU of ergocalciferol or cholecalciferol every three to six months also was beneficial in correcting low vitamin D levels in older community-dwelling adults and being treated in the outpatient setting (Gloth & Tobin, 1995). Clinical safety has been established in terms of renal function for calcium 500 mg twice daily and vitamin D 400 IU twice daily in people aged 64 and older (Brazier et al., 2005).

Screening with 25 OHD can be conducted in patients at risk for vitamin D insufficiency (malknourished, frail) and a treatment plan constructed to improve serum levels. Levels of 25 OHD are not drawn by all laboratories and may be expensive, costing about $50 per test (per review of published laboratory costs). Many patients with cancer undergo frequent blood assessments and an extra tube could be added to determine baseline 25 OHD. Trends in 25 OHD levels may help the healthcare team make recommendations for vitamin D and calcium supplementation.

Nurses must educate patients with cancer and their families concerning the risk of vitamin D insufficiency and some of the potential associated issues that may be ameliorated by improved vitamin D intake. Assessing the patient at regular intervals for vitamin D and calcium supplementation has been found to reduce the incidence of falls and is effective in maintaining sufficient vitamin D levels (Barr, Stewart, Torgerson, Seymour, & Reid, 2005). Rokhlin et al. (2007) suggested that calcium may play a role in promotion of prostate cancer cells; however, other researchers have not been able to support enhanced cancer promotion risk claims (Bonjour, Chevalley, & Fardellone, 2007). Assessing recent literature is important before suggesting vitamin D and calcium supplementation to older patients diagnosed with prostate cancer.

Evidence tends to support the use of vitamin D supplementation for older adults living independently in the community; however, more data are needed to understand precisely what dose will provide the benefits of reduced falls, improved functional status, increased time of survival with certain cancers, and reduction of the potential for some cancer diagnoses.

Regular assessment of functional status and falls also should be established in the nursing care plan. Functional status measures and other valid and reliable screening tools are available on the Try This series at www.geronurseonline.org. Assessment and screening instruments are important aspects of nursing assessment and can provide useful information on trends in functional status before, during, and after cancer treatment. Comprehensive screening in the older patient with cancer for issues such as depression, cognitive changes, fatigue, comorbidities, functional status, and other domains has been demonstrated to be effective evidence-based nursing practice (Overcash, 2003; Overcash et al., 2005). Evidence does exist on targeting older patients with cancer who are most likely to benefit from comprehensive screening (Overcash, Beckstead, Moody, Extermann, & Cobb, 2006; Overcash et al., 2005) and can be used with 25 OHD screening.

Although all data should be considered and discussed with the healthcare team, patient, and family, a reasonable dose on which to start to correct vitamin D insufficiency would be 600 IU, the ADA (2006) recommendation of vitamin D in conjunction with calcium (see Table 1). Vitamin D and calcium can be purchased over the counter for about $20 or less for generic per month. Preparations may vary; however, some have the ADA recommended vitamin D dose along with calcium combined into one tablet. Patients should take the vitamin D supplement with meals to reduce potential stomach upset.

Food choices are important to enhance vitamin D levels in older patients with cancer. Dairy, eggs, cereals with vitamin D and calcium added, salmon, and orange juice contain vitamin D. Approximately three serving per day of dairy and other foods containing vitamin D and calcium are recommended by the ADA. Dietary sources of calcium and vitamin D should be consumed throughout the day (not in bolus amounts) for best absorption. Older adults may require even more vitamin D to produce higher 25 OHD levels, adding to the importance of a diet rich in vitamin D and calcium (Vieth et al., 2005). Other ways to increase vitamin D and calcium levels are exposure to sunlight, walking, and other forms of aerobic exercise. Many factors affect sunlight exposure and vitamin D synthesis, such as season and geographic location. According to the National Institutes of Health Office of Dietary Supplements (2008), 5–30 minutes of sun exposure to the face, arms, legs, or back without sunscreen at least twice per week from 10 am–3 pm usually will lead to sufficient vitamin D synthesis.

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**Health maintenance in older patients with cancer can make curative treatment decisions possible, widen the extent of cancer screening, improve general clinical management, and enhance cancer treatment outcomes.**
For many African American men and women, vitamin D tends to be insufficient, possibly from pigmentation that reduces vitamin D production (Harris, 2006). African American men and women are encouraged to use vitamin D supplementation and consume foods rich in vitamin D and calcium. Many older adults experience vitamin D insufficiency and, therefore, fortification and supplementation of various food products are important (Calvo & Whiting, 2006). Calvo and Whiting found that the cost to fortify products with vitamin D is less than the agents used to treat many of the chronic diseases related to vitamin D insufficiency.

Table 1. Dosing Recommendations and Targeted Areas for Vitamin D and Calcium Supplementation

<table>
<thead>
<tr>
<th>VITAMIN D</th>
<th>CALCIUM PER DAY (mg)</th>
<th>INDICATION</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 IU per day</td>
<td>1,200</td>
<td>Bone health</td>
<td>American Dietetic Association, 2006</td>
</tr>
<tr>
<td>600,000 IU</td>
<td>–</td>
<td>Function</td>
<td>Dhesi et al., 2004</td>
</tr>
<tr>
<td>700–800 IU per day</td>
<td>–</td>
<td>Falls</td>
<td>Bischoff-Ferrari et al., 2005</td>
</tr>
<tr>
<td>400 IU per day</td>
<td>1,000</td>
<td>Falls and injury</td>
<td>Larsen et al., 2004</td>
</tr>
<tr>
<td>100,000 IU every three to six months</td>
<td>–</td>
<td>Falls</td>
<td>Cloth &amp; Tobin, 1995</td>
</tr>
</tbody>
</table>

Conclusions and Recommendations for Nursing Practice

Nurses should consider proactive interventions to maintain the health and independence of older patients undergoing cancer treatment. Data are convincing that vitamin D and calcium supplementation benefit overall health. Health maintenance in older patients with cancer can make curative treatment decisions possible (Kaasa, Torvik, Cherry, Hanks, & de Conno, 2007), widen the extent of cancer screening (Hefflin, Pollak, Kuchibhatla, Branch, & Oddone, 2006), improve general clinical management (Balducci & Yates, 2000), and enhance cancer treatment outcomes (D’Hondt et al., 2004). Optimizing health allows the patient to undergo a more robust chemotherapeutic regime. Instructing patients to consume vitamin D and calcium-enriched foods and use vitamin D supplementation may help establish a reasonable baseline health status that can sustain cancer treatment.

Patient and family education also is critical to enhancing vitamin D and calcium levels. Providing written material and links to Web sites, such as www.eatright.org and the National Institutes of Health information on dietary supplements at www.health.nih.gov, reinforces details provided by the nurse educator. The World Health Organization also has information on dietary supplements with respect to various regions around the world at www.who.int/nutrition.

Education about falls should contain details about vitamin D and calcium insufficiency, complete with dosing guidelines and signs and symptoms of toxicity and insufficiency. Motivating patients with cancer to include vitamin D supplementation to improve muscle strength and balance is a positive health behavior that can be achieved with little cost or effort on the part of providers, patients, and their families.

Many older patients with cancer have multiple comorbidities in addition to a cancer diagnosis (Oversca, 2007a). The average number of comorbid conditions in a person aged 70 and older is 5.6 (Fried et al., 2001) with osteoporosis as one of the most frequently occurring (National Center for Health Statistics, 2006).

Future research is necessary to explore specific dosing guidelines for vitamin D supplementation according to level of activity (independent or frail), gender, season of the year, and other modifying variables. Another consideration for the nurse is to identify the type of patient who will benefit from vitamin D supplementation, such as a patient who has been diagnosed with cancer and who may become gradually more dependent or frail. Vitamin D has many potential clinical applications, ranging from diminishing falls to reducing the likelihood of a cancer diagnosis, and may provide a low-cost, low-toxicity intervention in the care of the older patient with cancer.

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