

# All About Caffeine

## Clarifying the Controversies Surrounding Caffeine & Health

IFIC Foundation

Continuing Professional Education (CPE)  
Module for Dietitians



### **Objectives:**

1. Discuss history of caffeine, its sources and uses.
2. Understand how caffeine is metabolized by the body, and the physiological response to caffeine.
3. Learn the typical amounts of caffeine in various caffeinated beverages and how to calculate and consume moderate amounts from all sources.
4. Understand the science on the relationship between caffeine and various health conditions.
5. Explore potential benefits of caffeine being uncovered through new research.

# Introduction



- There is an extensive database made up of decades of scientific research on all aspects of caffeine and health, and yet....

*Confusion about caffeine persists*

Image source: Matthew Labutte



Caffeine needs almost no introduction. People have enjoyed foods and beverages containing caffeine for thousands of years. It is one of the most studied ingredients in the food supply. Even so, controversy and misperceptions about this food component persist.

This presentation will highlight some of the areas of caffeine confusion and shed some light on the science.

# History of Caffeine

- 2737 B.C.-- Chinese made tea using tea leaves
- 575 A.D. -- Coffee originated in Africa
- 11<sup>th</sup> century -- Arabians consumed coffee beverages
- 1519 -- Aztecs introduced chocolate to Spanish explorers
- 1880s -- First caffeinated soft drinks



Caffeine-containing foods and beverages have been enjoyed for thousands of years and today are still considered important aspects of numerous countries' cultures, as in the case of Chinese tea.

## Caffeine Sources & Use

- Naturally found in leaves, seeds, and fruits of plants
- Coffee, tea, chocolate and some soft drinks
- Used as a flavoring agent



Caffeine is found in the leaves, seeds, and fruits of numerous plant species worldwide. The most commonly known sources of caffeine are coffee and cocoa beans, guarana, and tea leaves.

Caffeine is a naturally-occurring component of coffee, tea and chocolate.

Caffeine is also added to some soft drinks for the bitter flavor that small amounts provide. This bitterness brings a desired balance to what might otherwise be considered by some to be an overly sweet taste.

# Caffeinated Beverages

- Moderation = 300 mg (about three 8-ounce cups of coffee)
- Caffeine content varies among and even within beverage types
- Average caffeine intake for adults ranges from 106-170 mg/day



- Primary sources of caffeine for adults: coffee, soda

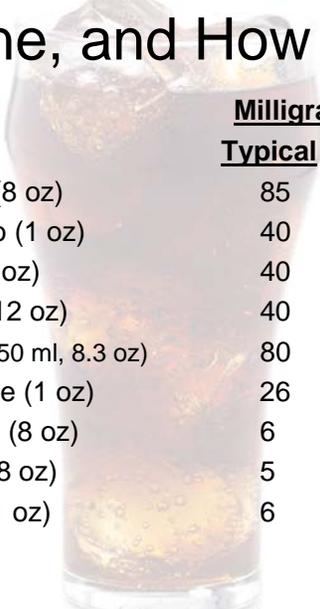


It is recommended that all sources of caffeine be consumed in moderation - the equivalent of three 8-ounce cups of coffee, or about 300 mg/day for adults.

The amount of caffeine in food and beverage products varies depending on the serving size, the type of product and preparation method. With coffee and tea, the plant variety also affects caffeine content. For example, more robust coffee beans have a higher caffeine content. Also, different brands of energy drinks can contain different amounts of caffeine.

Average caffeine intake for adults ranges from 106–170 mg/day (*Food & Chemical Toxicology, 2004*). Caffeine intake for adults 25 and older is provided mostly by coffee, followed by carbonated soft drinks. In older adults (65 years and older), coffee remains the primary source of caffeine, with tea replacing carbonated soft drinks as the secondary source of caffeine.

# Which Foods and Beverages Contain Caffeine, and How Much?



<u>Item</u>	<u>Milligrams (mg) Caffeine</u>	
	<u>Typical</u>	<u>Range</u>
■ Coffee, brewed (8 oz)	85	65 – 120
■ Coffee, espresso (1 oz)	40	30 – 50
■ Tea, brewed* (8 oz)	40	20 – 90
■ Cola soft drink (12 oz)	40	30 – 60
■ Energy drinks (250 ml, 8.3 oz)	80	50 – 160
■ Baker's chocolate (1 oz)	26	26
■ Cocoa beverage (8 oz)	6	3 – 32
■ Chocolate milk (8 oz)	5	2 – 7
■ Milk chocolate (1 oz)	6	1 – 15

\* Major U.S. Brands

Source: IFIC Review, Caffeine & Health: Clarifying the Controversies, 2008



This table shows the range of caffeine content of various foods and beverages. This can be a very helpful tool for determining patients' approximate total caffeine consumption. Measured against what is considered to be a safe and moderate daily caffeine consumption of 300 mg, you can see that one could enjoy up to three cups of coffee, or 7.5 cups of tea (based on the "typical" amounts above). Low-fat chocolate milk has a low level of caffeine and is a delicious way to include calcium in the diet.

# Caffeine Metabolism



- Mild central nervous system stimulant
- Effects of caffeine can vary due to individual sensitivity
- Caffeine's half-life (time to metabolize half the amount consumed) is approximately five hours



Caffeine does not accumulate in the body over time and is normally excreted within several hours of consumption. This time varies among individuals, but healthy adults usually metabolize caffeine quickly. Caffeine metabolism is typically discussed in terms of the half-life, or time for the body to excrete half the amount. The half-life of caffeine is approximately 5 hours.

The effects of caffeine vary from person to person. Caffeine sensitivity and health effects depend on many factors, including the frequency and amount of regular intake, rate of metabolism, body weight, and physical health.

Some individuals can consume caffeinated products late in the evening without it affecting their ability to sleep. Others find even a small amount of caffeine keeps them awake. Individuals tend to find their own acceptable level of daily caffeine consumption through trial and error. People who experience undesirable effects can easily adjust their caffeine consumption to meet their needs.

## Is Caffeine “Addictive”?

- No.

“Addiction involves compulsive and repeated use of a substance that poses a threat to physical, social and economic health.... substance dependence is built around persistence in procuring the substance of choice, in the face of obstacles, and despite psychological, social and economic costs.” -*Drewnowki & Bellisle, 2007*

Caffeine does not fit the criteria for addiction according to the American Psychiatric Association



Moderate caffeine consumption is safe and should not be classified with addictive drugs of abuse.

Depending on the amount of caffeine consumed, it can be a mild central nervous system stimulant. Although caffeine is sometimes characterized informally as “addictive,” the American Psychiatric Association does not recognize daily caffeine consumption as an “addiction” that has “withdrawal” symptoms.

According to the American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders, 4<sup>th</sup> edition (DSM-IV, 1994) and paraphrased by Drewnowski and Bellisle (2007),

“Addiction involves compulsive and repeated use of a substance that poses a threat to physical, social and economic health.... substance dependence is built around persistence in procuring the substance of choice, in the face of obstacles, and despite psychological, social and economic costs.”

When regular caffeine consumption is stopped abruptly, some individuals may experience mild, temporary symptoms of discomfort such as headache, fatigue, or drowsiness. The effects are relatively mild for most people, and can be reduced avoided completely by gradually reducing caffeine intake over several days.

# Caffeine & Children

- Except for infants, children metabolize caffeine more quickly than adults.
- However, pound for pound, children are no more sensitive to caffeine than adults.
- Primary caffeine sources for children: tea, soft drinks
- Energy drinks are increasing in popularity
  - Some products contain more than one serving
  - Check the label for servings and caffeine content (if available)
  - Caffeine content varies between products



Children consume much less caffeine than adults, even in proportion to their size [Knight et al, 2004]. The average consumption for children ages 1-5 and 6-9 years is 14 and 22 mg/day, respectively. Children, except for infants, metabolize caffeine more quickly than adults.

For children and young adults, the main sources of caffeine are tea and soft drinks. Contrary to popular belief, children, including those diagnosed as hyperactive, respond to caffeine similarly to adults. Further, according to a study by Leviton (1992), there is no evidence of an association between caffeine and hyperactive behavior.

There is little scientific evidence to support the restriction of caffeine use in children. However, because children's nervous systems are still developing, Health Canada recommends that children consume no more than 2.5 mg/kg of caffeine per day, or 37.5 - 45 mg/day for a 1-5 year old and 87.5 - 125 mg/day for a 10-14 year old—amounts that are much higher than current consumption. Overall, it is prudent to advise that children consume caffeine in moderation and appropriate to their size.

Energy drinks are increasing in popularity among adolescents and young adults. Ounce for ounce, energy drinks may contain about the same amount of caffeine as coffee; however, some energy drink products provide more than one serving per container, so it is important to read the product label to know how many servings, and therefore how much caffeine, the full product contains. In addition, they may also contain additional sources of caffeine from guarana, and other botanical sources of caffeine-like compounds, which may not be declared as caffeine on the label. While caffeine is required to be listed in the ingredients list, the amount is not, although some energy drink manufacturers voluntarily list caffeine content on labels or provide this information on the product's Web site.

# Women's Health



- Conflicting information about caffeine and women's health have led to confusion about the safety of caffeine-containing foods and beverages
- Research supports moderate consumption of caffeine for women, including those who are pregnant, nursing, or post-menopausal.



Key medical and scientific experts, as well as government agencies such as the U.S. Food and Drug Administration (FDA), concur that caffeine can be consumed in moderation by pregnant and lactating women. However, pregnancy and aging may affect a woman's sensitivity and metabolism of caffeine, so they should talk to their health care provider about their caffeine consumption.

Numerous scientific studies have examined caffeine and various aspects of women's health, including fertility, miscarriage, bone health and breast disease. Many physicians and researchers today agree that most women can safely consume caffeine in moderation, which is about 300 mg per day, or approximately three 8-ounce cups of coffee.

The next few slides will discuss different aspects of women's health as they relate to caffeine consumption.

# Caffeine & Reproductive Health

- Fertility: No association between total caffeine consumption and reduced fertility.
- Miscarriage: Most research has found no conclusive evidence that moderate caffeine intake has adverse effects on pregnancy or pregnancy outcome.
- While some studies have reported a link, study limitations and confounding factors can't be ruled out as causing the results.



The vast majority of scientific research indicates that moderate caffeine consumption does not affect fertility.

Although some of the earlier studies conducted on this subject suggested that consumption of caffeine may delay conception, several larger and more recent studies have found that caffeine consumption has little or no effect on the ability to conceive, and is not a risk factor for infertility.

A 2003 comprehensive epidemiological review by Nawrot et al concluded that caffeine intake of 300 mg/day or less does not reduce fertility in otherwise fertile women. In 2006, Higdon and Frei suggested that women experiencing difficulty conceiving limit caffeine consumption to less than 300 mg/day, in addition to eliminating tobacco and alcohol use. A 2005 study conducted by Sata et al in Japan found that only women having a particular genetic background (homozygous CYP1A21F alleles) are at increased risk of reduced fertility due to caffeine consumption.

Many studies have been conducted to examine the association between caffeine and miscarriage and birth defects. In some cases, results have been conflicting due to methodological issues with the research. For example, Savitz et al (2008) found that caffeine consumption of 200 mg/day does not increase the risk of miscarriage. Conversely, Weng et al (2008), found that 0-200 mg/day of caffeine was associated with increased miscarriage risk. However, in the Weng study, 59% of the women had already miscarried when they reported their caffeine intake to the researchers (compared to 29% in the Savitz study), introducing the possibility of recall bias.

Pregnant women may wish to consult their health care provider about caffeine use. Reducing caffeine intake during early pregnancy may be advisable if you consume more than 300 mg (or three 8-ounce cups) of coffee per day or if you have a sensitivity or other health factor that can be determined by your doctor.

## Caffeine & Breastfeeding

- The caffeine in 2-3 cups of coffee per day does not usually affect breastfeeding infants
- Three or more cups of coffee may lead to increased wakefulness and poor feeding for the baby



The American Academy of Pediatrics (AAP) Committee on Drugs Policy Statement states that caffeine consumption (equivalent to 2-3 cups of caffeinated beverages per day) is usually compatible with breastfeeding. Although caffeine is passed from the mother to the infant through breast milk, the amount is small and, if maternal caffeine consumption is not excessive, should not have an effect on the baby.

Large amounts of caffeine, however, may cause some nursing infants to become irritable or may affect sleeping patterns, so practicing moderation is key.

Reference: American Academy of Pediatrics, Committee on Drugs, Transfer of Drugs and Other Chemicals into Human Milk. PEDIATRICS Vol. 108 No. 3 September 2001, pp. 776-789. Accessed March 25, 2009. Available at: <http://aappolicy.aappublications.org/cgi/reprint/pediatrics;108/3/776.pdf>

# Fibrocystic Breast Disease (FBD)

There is no  
association  
between caffeine  
and breast  
changes, FBD,  
tumors, or  
tenderness.



Fibrocystic breast disease (FBD) is one of the conditions that is most often, and also incorrectly, linked to caffeine consumption. Anecdotal reports of a correlation between caffeine and breast tenderness, benign tumors, and/or breast changes have been part of medical folklore since the early 1970s when one researcher published several studies on caffeine and FBD. Although the studies found no connection between caffeine and FBD, some women in the studies reported less tenderness when they eliminated caffeine.

FBD is a condition characterized by multiple cysts that can be felt throughout the breast and are usually associated with pain or tenderness. In 1986, the National Cancer Institute conducted a case control study of 3,000 women and found no connection between caffeine and benign breast tumors, FBD, or breast tenderness (Schairer, et al., 1986). Leading health and medical organizations such as the American Medical Association have stated there is no evidence of an association between caffeine intake and fibrocystic breast changes.

# Caffeine & Osteoporosis



- Moderate caffeine intake is not a threat to bone health.
- Calcium lost from consuming one cup of coffee per day can be offset by adding just two tablespoons of milk to the coffee.
- Adequate calcium is vital, regardless of caffeine intake.



Osteoporosis is a bone disease characterized by a decrease in bone density and the development of weak and brittle bones that are more prone to fracture. Risk factors include inadequate calcium intake, high protein intake, smoking, inadequate exercise, genetics, small body frame, low estrogen levels and age.

Caffeine intake at high levels (>744 mg/day, or about 7.5 cups of coffee) has been found to increase urinary excretion of calcium and magnesium [Tucker, 2003]. However, calcium lost from consuming one cup of coffee per day can be offset by adding just two tablespoons of milk to the coffee [Ilich and Kerstetter, 2000].

Numerous studies on caffeine's effects on bone loss/osteoporosis risk have been conducted over the years. Studies examined women throughout their life spans (adolescence through post-menopause). Nawrot et al concluded in their review that moderate caffeine intake is not a threat to bone health; lifetime consumption of caffeine at levels higher than 400 mg/day (approximately 3-6 cups of coffee/day), along with calcium consumption of less than 800 mg/day, may have a negative impact on calcium metabolism and bone health. Therefore, while caffeine does not cause bone loss, it is important to get enough calcium in the diet [Nawrot et al., 2003].

## Caffeine and Cardiovascular Disease (CVD)

- Blood Pressure: Some people may experience a temporary, minor rise in blood pressure after consuming caffeine, similar to climbing a flight of stairs.
- Blood Lipids: Increases are associated with unfiltered coffee, which is not commonly consumed in the U.S.



More than 100 studies have examined whether an association exists between caffeine consumption and blood pressure, cardiac arrhythmia or coronary heart disease (CHD). Studies examining caffeine and blood pressure have shown that caffeine may cause a temporary and modest rise in blood pressure, especially for those who don't consume caffeine regularly. Regular consumers of caffeine quickly build up tolerance to this effect, which is less than that normally experienced when climbing a flight of stairs. However, caffeine does not cause chronic hypertension or chronic increases in blood pressure. People already suffering from high blood pressure should consult with their health care provider about their caffeine consumption, since they may be more sensitive to its effects [Winkelmeier et al, 2005].

Studies have also examined whether coffee or caffeine are linked to either cardiac arrhythmias (abnormal heart beats) or stroke. Nawrot et al. concluded that there is no association between caffeine and arrhythmia. While coffee consumption and stroke has been studied less frequently, only one study has shown an increased association between coffee consumption (about 300 mg/day, or three 8 oz. cups) in high-risk men with hypertension (n=499) and stroke. More research is needed to determine whether coffee or caffeine consumption increases the risk of stroke in hypertensive individuals. Those who have survived a stroke should seek advice from their physician regarding caffeine consumption.

Research on the cardiovascular effects of caffeine has concluded that consuming moderate amounts of caffeine (up to 400 mg/day) in the form of coffee is not associated with any increased risk of cardiovascular disease (CVD). However, Nawrot (2003) states that the epidemiological data is insufficient for drawing conclusions about the effects of coffee on CVD at higher doses (1,000 mg/day or more, or at least 10 cups of coffee per day).

# Caffeine & Cancer



- Caffeine has not been found to cause any type of cancer in animal or human studies.
- In fact, caffeine can *protect* against some types of cancer, including liver, colon, and colorectal cancers.



Most of the research conducted on cancer and caffeine is based on coffee and tea consumption. However the majority of this research shows a positive effect of caffeine.

According to the World Health Organization (WHO) International Agency for Research on Cancer (IARC) 1997 monograph evaluating the carcinogenic effects of coffee and tea, there is no evidence that caffeine is carcinogenic in either animal or human studies. Nawrot et al (2003) also concluded that caffeine is unlikely to be carcinogenic at levels below 500 mg, or five cups of coffee per day.

Overall, research evidence has found that caffeine does not cause breast, bowel, bladder, pancreatic, or ovarian cancer, and may even be protective against liver, colon and colorectal cancers.

## Caffeine & GERD



- Gastro-esophageal reflux disease (GERD), or heartburn, is caused by compounds in coffee.
- Studies on GERD do not support avoidance of caffeinated beverages.



Studies have found that consuming decaffeinated coffee may reduce the symptoms of GERD, but that consuming tap water with and without added caffeine had no effect. In addition, drinking coffee with reduced levels of caffeine still caused GERD. This evidence has led many researchers to conclude that GERD is caused by other components in coffee, not caffeine.

In addition, a large review of 2,039 studies conducted between 1974 and 2004 found that the only thing that helps alleviate symptoms of GERD is sleeping with the head elevated. All other lifestyle changes, including dietary changes, did not improve symptoms [Kaltenbach et al, 2006].

# Caffeine & Performance



- Caffeine has been shown to increase mental alertness and enhance physical performance. Caffeine has been linked to
  - Improved endurance and athletic performance
  - Increases in alertness, concentration and mental acuity
  - Enhanced mood



Consuming caffeine in moderation has been shown to have a positive effect on both physical and mental performance.

Studies have found that individuals who consume as little as 32 mg of caffeine/day may experience increased memory and improved reasoning abilities (Lieberman, 2001). Research has also found that caffeine consumption can improve reaction time and auditory and visual accuracy.

In addition, a 2007 study of coffee intake in France showed that women who drink at least three cups of coffee per day have a slower rate of cognitive decline (Ritchie, et al., 2007). Caffeine was identified as the ingredient most likely to be responsible for this effect.

Caffeine has also been shown through scientific research to enhance muscular endurance for rowers, cyclists and runners. While the amounts of caffeine (6 or 9 mg/kg) used in these studies is equivalent to five or seven 8-ounce cups of coffee, the benefits of smaller amounts of caffeine (1.5 mg/kg, or 10 ounces or just over one cup of coffee) have also been shown to improve performance, particularly during the latter part of endurance events.

In the past, it was thought that caffeine improved endurance by boosting fat utilization during exercise. However, researchers now think that caffeine lowers the threshold for exercise-induced beta-endorphin and cortisol release, the hormones associated with feelings of well-being known as the “runner’s high” (Laurent, 2000).

## Caffeine & Hydration

- Caffeinated beverages are not dehydrating.
- Caffeine consumption does stimulate mild diuresis, but this is offset by the liquid in the beverage and is no more of a diuretic than water.
- Tolerance to caffeine reduces the chance of fluid imbalance.



A literature review on caffeine and hydration found that advice to prevent dehydration by avoiding caffeinated beverages is not supported by the science. According to the Institute of Medicine (IOM), caffeine-containing beverages can contribute to total daily water intake, as can other beverages such as milk and juice, and watery fruits and vegetables [IOM, 2004].

Caffeine can have a different impact on hydration depending on whether an individual is at rest or participating in an endurance activity such as long distance running or cycling. At rest, caffeine consumption increases urine production; however, during an endurance event, caffeine does not have this effect and does not deplete electrolytes [Armstrong, 2005].

Nevertheless, it is not necessary to avoid caffeinated beverages in the summer months to stave off dehydration. It is more important to consume enough fluids. Those individuals who don't like water can still stay hydrated with other beverages, including caffeinated beverages.

## Emerging Science: Potential Benefits of Caffeine

- Reduced risk of type 2 diabetes
- Reduced risk of Parkinson's in men
- Reduced risk of cognitive decline in women
- Reduced risk of chronic liver disease
- Improved immune function and anti-inflammatory properties



New research is revealing several potential health benefits of caffeine. Most of this research has been conducted with coffee as the source of caffeine. Some areas for potential benefits include:

**Type 2 Diabetes:** Clinical studies conducted in both animals and humans, as well as large prospective cohort studies, have demonstrated that both coffee and caffeine improve glucose metabolism and tolerance, can improve or increase insulin sensitivity, and can reduce the risk of developing impaired glucose tolerance. In a 2005 review of nine cohort studies (193,000 men and women), the authors found a 35% lower risk of type 2 diabetes in people who consumed at least six cups of coffee per day and a 28% lower risk for those drinking between four and six cups per day, compared with people who drink fewer than two cups per day [Van dam and Hu, 2005].

**Parkinson's Disease:** Studies indicate that coffee, tea and other caffeinated beverages may help to reduce the risk, or delay the onset, of Parkinson's disease **in men**. Caffeine is thought to protect brain cells that release dopamine (dopaminergic neurons). In several large-scale epidemiological studies, including the Honolulu Heart Program, Nurses' Health Study and the Health Professionals' Follow-Up Study, coffee consumption significantly reduced the likelihood of developing Parkinson's Disease [Ascherio et al 2001, Ross and Petrovitch 2001, Schwarzschild et al 2002].

**Alzheimer's Disease:** Studies on Alzheimer's in rabbits found regular caffeine ingestion equivalent to one cup of coffee per day by a human adult protected against the disruption of the blood brain barrier, a precursor condition to the development of Alzheimer's disease [Chen et al 2008]. Other research in mice has found a protective effect of caffeine for Alzheimer's Disease (Arendash, 2009). More research is being conducted in this promising area.

**Chronic Liver Disease:** Analysis of NHANES data (1988-1994) shows that consuming either coffee or caffeine decreases the risk of abnormally elevated alanine aminotransferase (ALT) activities [Ruhl and Everhart, 2005]. In addition, Ruhl and Everhart conducted a prospective study in 2005 and found that those who drank more than 2 cups of coffee or tea per day had less than half the risk of developing chronic liver disease as those who drank less than one cup per day. Several case-control studies have found that coffee consumption reduces the risk of cirrhosis (chronic inflammation of the liver).

**Immune Health:** In 2006, Horrigan et al conducted a review of caffeine's effects on the immune system, which indicated that caffeine has an anti-inflammatory effect at levels of 400-600 mg, or about 4-6 cups of coffee, per day, which could benefit the immune system.

## What This All Means

- Overwhelming scientific evidence shows moderate caffeine consumption to be safe for the general healthy population.



- Researchers continue to study caffeine and health issues
- There may be some health benefits associated with moderate caffeine consumption.
- Sensitivities to caffeine vary among individuals.
- Moderation is key.



For the overall healthy population, consumption of 300 mg of caffeine or less per day is considered safe and may have some potential benefits. Sensitive sub-populations should consult their physician if they have any concerns. As with most things, moderation is the key.

# Where to Find Science-Based Information on Caffeine

## IFIC Review

### *Caffeine & Health: Clarifying the Controversies*

[http://www.ific.org/publications/reviews/upload/Caffeine\\_v8-2.pdf](http://www.ific.org/publications/reviews/upload/Caffeine_v8-2.pdf)



More information about caffeine and health can be found in the International Food Information Council Foundation Review: “Caffeine and Health: Clarifying the Controversies”, on our Web site at [http://www.foodinsight.org/Resources/Detail.aspx?topic=IFIC\\_Review\\_Caffeine\\_and\\_Health\\_Clarifying\\_the\\_Controversies](http://www.foodinsight.org/Resources/Detail.aspx?topic=IFIC_Review_Caffeine_and_Health_Clarifying_the_Controversies). This additional source of information on caffeine and health provides a comprehensive overview of the latest research, as well as the references for the citations in this module.

For more information about the International Food Information Council Foundation, visit [www.foodinsight.org](http://www.foodinsight.org).

All images purchased from ©iStockphoto.com unless otherwise noted.