

## **Nutrition Guidelines for Neutropenic Oncology Patients**

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A priority for RDs is to educate individuals about beneficial diet recommendations that improve their health outcome. Oncology patients often undergo treatments that cause neutropenia, or a drop in infection-fighting neutrophils, and frequently are encouraged to follow a neutropenic diet to decrease their exposure to potentially harmful bacteria. However, the use of the neutropenic diet has been under scrutiny because of the lack of consistent evidence to support its benefit.

This continuing education course explores the research about and controversy surrounding the use of the neutropenic diet for oncology patients in inpatient and outpatient settings. It also provides insight into the movement to educate patients about food safety guidelines in lieu of recommending a neutropenic diet.

### **What Is Neutropenia?**

Neutrophils are the most common type of white blood cell circulating in the body and the cells that first respond to infection. Neutropenia is a condition characterized by too few neutrophils circulating in the blood. This may occur because of the increased destruction and/or decreased production of neutrophils as a side effect of cancer-related treatment.<sup>1</sup>

The National Cancer Institute defines neutropenia as an absolute neutrophil count (ANC) below 1,500/mm<sup>3</sup>. An ANC from 500 to 1,000/mm<sup>3</sup> is considered severe neutropenia and below 500/mm<sup>3</sup> is life threatening.<sup>1</sup> However, the definition of neutropenia and the criteria for using the neutropenic diet vary from institution to institution.

The most common causes of neutropenia include disease of the bone marrow (eg, leukemia), viral infections such as HIV, and the use of chemotherapy and other cancer-related treatments such as bone marrow transplantation, which interfere with neutrophil production within the bone marrow.

The most important function of the bone marrow is maintaining a healthy immune system by way of producing an adequate number of infection-fighting white blood cells. When white blood cell production drops, the immune system becomes increasingly incompetent and neutropenia ensues.

Neutropenia is a life-threatening condition. Approximately 75% of the deaths in patients with leukemia and 50% of the deaths in patients with solid tumors are related to neutropenic

infections.<sup>2</sup> Neutropenia is difficult to prevent in cancer patients undergoing treatment because chemotherapy and radiation can suppress the bone marrow and destroy neutrophils.

It's theorized that the risk of developing an infection would decrease by limiting the introduction of bacteria from environmental sources and exposures, including food, via the gastrointestinal tract. Bacteria can pass from the intestinal lumen through the mucosal epithelium and into the body when mucosal damage occurs. Chemotherapy often causes inflammation and mucosal damage that disrupts the normal environment of the gastrointestinal tract. Because of the intestinal damage, bacterial translocation has more potential to occur in patients undergoing chemotherapy. When the bacteria pass through the intestinal mucosa, they can move to the lymph system and on to other organs. The inadequate number of neutrophils limits the ability for the immune system to fight the invaded bacteria.<sup>3</sup>

Newer medications, called colony-stimulating factors such as Filgrastim (Neupogen), pegfilgrastim (Neulasta), and sargramostim (Leukine or Prokine) help the body make more neutrophils. The exogenous administration of these medications stimulates the stem cells in the bone marrow to produce more infection-fighting white blood cells. Before these medical interventions were available, implementing a neutropenic diet was done as one precaution to help prevent life-threatening infections in patients with neutropenia.

### **Neutropenic Diet**

The neutropenic diet is a general description used synonymously with the low-bacterial diet, the low-microbial diet, and the immunosuppressed diet. The diet composition varies widely. One of the oldest versions, called the sterile diet, is the most restrictive and requires the use of a separate sterilized kitchen, with food prepared in a way that kills all bacteria and fungi.

The low-bacterial or low-microbial diet includes well-cooked foods and prohibits foods that are potentially harmful, such as raw fruits and vegetables and their juices, undercooked eggs, unpasteurized dairy products, deli meats, and undercooked meats. The most common foods restricted by institutions are raw fruits and vegetables. These are replaced by cooked, canned, or prepackaged foods.

Institutions started implementing the neutropenic diet nearly 50 years ago after Bodey and colleagues identified the relationship between low neutrophils and infection risk.<sup>4</sup> The neutropenic diet, designed to exclude foods that could introduce bacteria into the gastrointestinal tract, evolved as one part of a sterile environment created for patients with neutropenia to reduce infection risk.<sup>5,6</sup>

There is potential for bacteria to contaminate food all along the food chain. If food is handled inappropriately, bacteria can enter the body, increasing the potential for infection. Many foods are known to have microorganisms growing on them. The FDA links raw and undercooked meats, fish, and eggs; raw fruits and vegetables and their juices; and unpasteurized dairy products to infections from organisms such as *Salmonella*, *E coli*, and *Cyclospora*.<sup>7</sup>

## **Institutional Practices**

Skeptics of the neutropenic diet argue that it's unnecessary to impose nutritional restrictions on a population at nutritional risk because there's only limited convincing evidence that a neutropenic diet reduces infection risk in the oncology population.

The controversy that surrounds the implementation of the neutropenic diet is a result of the lack of convincing, up-to-date, randomized controlled trials. Without adequate research, standardized neutropenic diet guidelines haven't been developed for institutional use. Institutions strive to formulate their practices based on evidence from well-conducted research studies; nevertheless, some institutions implement a version of the neutropenic diet based on theory and years of clinical practice. Others refuse to implement the diet, citing a lack of support for it from current research. Many institutions now prescribe a modified neutropenic diet based on the FDA food safety guidelines for people with cancer.<sup>8</sup>

Some institutions implement a neutropenic diet for specific subsets of patients, such as those undergoing hematopoietic stem cell transplantation. These individuals are at risk because the high-dose chemotherapy and radiation therapy they receive often results in more prolonged and profound neutropenia.

Even without standardized guidelines, many institutions and practitioners continue to use the neutropenic diet. A study conducted in 2000 surveyed 156 institutions that belonged to the Association of Community Cancer Centers, finding that 78% of these institutions restricted the diets of their neutropenic patients. Of the institutions that implemented restrictions, 95% restricted fresh vegetables, 92% restricted fresh fruit/juice, and 74% restricted raw eggs.<sup>9</sup> A recent survey of pediatric oncologists found that more than half of responding physicians instituted a variation of the neutropenic diet, and the decision to do so was predominately based on absolute neutrophil count. Centers with stem cell transplant programs were more likely to institute a neutropenic diet. Physicians within the same institution varied considerably on the timing and criteria for initiation, foods restricted, and duration.<sup>10</sup> A study published in 2014 surveyed dietitians in the United Kingdom and found that almost 70% of dietitians institute neutropenic diet restrictions for neutropenic patients. Dietitians specializing in oncology or hematology were more likely to institute neutropenic restrictions, and the foods restricted and time of initiation varied considerably.<sup>11</sup>

A study conducted in 2001 found that five of seven pediatric hospitals implemented a low-microbial diet for pediatric bone marrow transplantation patients. Dietary practices ranged from food prepared in a separate sterilized kitchen to the use of mandatory food safety guidelines within the institution's kitchen. The two hospitals that provided a regular diet did so because of lack of concrete evidence supporting the neutropenic diet.<sup>12</sup>

Although these are the most recent studies surveying institutions to determine neutropenic diet practices, the results are out of date and don't reflect the evolution of medical treatments in the past decade. Since this is an area of ongoing debate, future studies are being planned and/or conducted with the hopes that new information will help guide institutional practices.

## **Organization Guidelines**

Institutions and practitioners often utilize evidence-based guidelines developed by leading oncology organizations as a basis for the policies they implement. However, the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology for Prevention and Treatment of Cancer-Related Infections, Version 1.2012 doesn't mention implementing the neutropenic diet.<sup>13</sup>

The American Society of Blood and Marrow Transplantation only recommends a neutropenic diet after hematopoietic stem cell transplantation. It acknowledges that this recommendation is based on observation and not supported by evidence-based studies in the hematopoietic stem cell transplantation population. It recommends that the patients' nutritional status and quality of life should be taken into account before implementing the neutropenic diet.<sup>14</sup>

The Academy of Nutrition and Dietetics (the Academy) ***Nutrition Care Manual*** recommendation for a low-microbial diet is based on the USDA food safety guidelines and guidelines from the Fred Hutchinson Cancer Research Center.<sup>15</sup> The Academy's Oncology Dietetics Practice Group developed an oncology textbook, ***Oncology Nutrition for Clinical Practice***, that's used as a key reference for the specialist in oncology nutrition board certification examination. However, there's no recommendation for the use of the neutropenic diet within this clinical practice textbook.<sup>16</sup>

## **Neutropenic Diet and Infection Rate**

There are a few studies investigating infection risk and the neutropenic diet. The table below summarizes the research since 2000. In a compilation and analysis of the research prior to 2000, Wilson concluded that the literature failed to show that a neutropenic diet prevented infection in patients who had chemotherapy-induced neutropenia.<sup>17</sup>

**Table 1**

| Studies on Neutropenic Diet                      |      |   |  |  |  |
|--|------|---|--|--|--|
| Study  | Year | Purpose   | Population   | Study Design/ Outcome                                  | Findings/Conclusion  |
| DeMille  | 2006 | To determine the effects of the neutropenic diet in compliant vs noncompliant patients in the outpatient setting              | 28 patients; average age of 50 following a neutropenic diet  | Pilot study  | Fifty-seven percent of participants complied with the diet; no statistically significant difference in febrile admissions between compliant and noncompliant participants.   |
| Moody*   | 2006 | To determine rate of febrile neutropenia, diet adherence, and tolerability  | 19 pediatric oncology patients randomized to follow food safety guidelines or neutropenic diet   | Multicenter, prospective, randomized, controlled trial | No statistically significant difference in febrile illness; adherence and tolerability were comparable between the two groups.   |
| van Tiel*  | 2007 | To determine whether a normal hospital diet is safe compared with a low-bacterial diet given to prevent infection             | 20 cytopenic patients on antimicrobial prophylaxis randomized to normal hospital diet or low-bacterial diet  | Randomized, controlled pilot study                     | No statistically significant difference in gut colonization or infection rate between the two groups.  |
| Gardner*   | 2008 | To determine rates of major infection and death between individuals on a cooked diet vs a diet with raw fruits and vegetables | 153 acute myeloid leukemia or high-risk myelodysplastic syndrome patients admitted to a protective environment; randomized to cooked diet or diet with raw fruits and vegetables | Prospective, randomized trial                          | Little benefit from a neutropenic diet in newly diagnosed acute myeloid leukemia or high-risk myelodysplastic syndrome patients undergoing remission induction therapy in a protective environment                               |
| Trifilio   | 2012 | To determine the effects of a general diet vs a neutropenic diet on infection rate  | 726 hospitalized stem cell transplant recipients, 363 placed on the general diet and 363 placed on the neutropenic diet  | Retrospective study                                    | Statistically significant increase in infections in the neutropenic diet group compared with the general diet.   |
| van Dalen  | 2012 | Systematic review to determine efficacy of low bacterial diet in preventing infections and decreasing mortality               | 3 randomized control trials (*) above met criteria for inclusion which involved a total of 192 patients  | Cochrane systematic reviews                            | All studies had methodological concerns and data was not able to be combined for analysis. Although no evidence of effect was seen, the lack of high quality research prevents systematic conclusion or clinical recommendation. |
| Studies on Probiotic Use in Neutropenic Patients |      |   |  |  |  |
| Mego   | 2013 | To determine the safety of probiotic use in cancer patients undergoing chemotherapy and radiation therapy                     |  | Systematic review                                      | Evidence is limited, and further well- designed clinical trials are needed.  |

\*Study met criteria for inclusion in 2012 Cochrane review

### **Inpatient**

Additional studies published after 2000 continue to show no benefit from implementing the neutropenic diet in the inpatient setting. A randomized, prospective study conducted in 2008 concluded that the neutropenic diet didn't prevent major infection or death in an acute myeloid leukemia population receiving chemotherapy.<sup>18</sup>

A randomized, controlled pilot study investigated the infection rate in cytopenic oncology patients who were receiving antimicrobial prophylaxis and prescribed either a low-bacterial diet or a normal hospital diet. The researchers reported no difference in infection occurrence or the colonization of bacteria and yeasts in this population.<sup>19</sup>

Additionally, a large, retrospective study found higher infection rates in hematopoietic stem cell transplant recipients on the strict neutropenic diet compared with those on a general diet. Authors suspect that decreased bacteria in the gastrointestinal tract of the patients following the neutropenic diet may have increased their risk of *Clostridium difficile* infection.<sup>20</sup>

### **Outpatient**

More oncology patients are being treated in the outpatient setting, and there's still a threat of neutropenia after outpatient treatment. One pilot study found no difference in the rate of febrile admissions or the rate of positive blood cultures between compliant and noncompliant participants in the outpatient setting.<sup>21</sup>

The neutropenic diet is also used in the pediatric population. However, one study found no difference in febrile illness in pediatric patients randomized to follow food safety guidelines or neutropenic diet guidelines.<sup>22</sup>

### **Published Literature Reviews**

The published literature reviews to date further support that there is no conclusive evidence to support the use of the neutropenic diet. In addition, leading cancer centers such as Memorial Sloan Kettering Cancer Center and Seattle Cancer Care Alliance implement a variation of the neutropenic diet for cancer patients after chemotherapy, radiation, and/or bone marrow transplantation. Their practices are consistent with the food safety guidelines provided by the FDA with minor modifications for their institutions.

A 2012 review article published in ***Oncology*** concluded that there's no clear benefit of imposing a restrictive diet during periods of neutropenia.<sup>23</sup> A Cochrane systematic review published in 2012 concluded there wasn't conclusive evidence to recommend using the neutropenic diet for prevention of infections and related outcomes.<sup>24</sup> A 2014 literature review published in the ***Clinical Journal of Oncology Nursing*** reviewed studies published since the 2009 review by Tarr and Allen<sup>25</sup> and suggested that practices move away from the traditional neutropenic diet to more focus and education on food safety.<sup>26</sup>

### **Educating Individuals on Food Safety Guidelines**

As an alternative to the neutropenic diet, some institutions are limiting their recommendations to urging strict adherence to the FDA's food safety guidelines designed for people with cancer, and to the USDA's Food Safety and Inspection Service guidelines.<sup>8</sup> For some individuals, it

may be easier to adhere to food safety guidelines than to the restrictions of the neutropenic diet. One study found this to be true for the families of pediatric oncology patients.<sup>22</sup>

There are potential benefits to using food safety guidelines in place of a restrictive diet. Hospitalized patients benefit because they're offered more varied menu selections, which may lead to increased oral intake and better satisfaction. In the outpatient setting, individuals have greater freedom in food selection, making meal preparation easier for both the individual and caregivers.

Based on their expertise, the authors gathered the following information in order to help fellow RDs incorporate the appropriate food safety guidelines in both the inpatient and outpatient settings:

### ***Inpatient Setting***

In the inpatient setting, the nutrition staff routinely carries out food preparation under strict, mandated food safety guidelines. This is the time and place to begin educating patients and instill simple, practical habits such as hand washing before consuming foods. RDs should involve the other members of a patient's care team, including nurses and nutrition service staff, to help the patient follow any recommended guidelines. For example, the meal delivery staff should be taught to remind patients to wash their hands or, for nonambulatory patients, ask the staff provide them with bottles of hand sanitizer.

Patients in the inpatient setting are often overwhelmed by medical procedures, emotions, and new information and may forget instructions when they return home. Therefore, it's important to provide written materials with the RD's contact information to facilitate a smooth transition to the home setting.

### ***Outpatient Setting***

Outpatient education sessions are good opportunities to build on any inpatient education that the patients may have obtained. Focus on the FDA's four basic steps to food safety—cleaning, separating, cooking, and chilling—and brainstorm ideas that will make implementing these guidelines easier in their individual situations.

Whether educating individuals in the inpatient or outpatient setting, it's important to gear the education session to the unique needs of the individual and the family. After determining who will be responsible for food preparation for the patient and what that person's educational level and knowledge base is, the RD can individualize the teaching to the needs that have been identified. Nutrition education should then focus on the following recommendations and guidelines:

- Provide practical recommendations to patients for keeping their hands clean. Encourage individuals to keep hand sanitizer easily accessible, such as in their purses, pockets, cars, or next to their beds. Review when hand washing is necessary and the appropriate way for patients to wash their hands.

- Explain the importance of reducing the risk of cross-contamination to prevent bacteria from spreading from one food to another. Some individuals aren't aware of the importance of keeping raw foods separate from ready-to-eat foods.
- Discuss grocery shopping tips that will help ensure safety. Encourage individuals to take advantage of the available bags to cover packaged raw meat and fresh produce to keep these items separated throughout the shopping trip.
- Discuss how individuals store raw food in their refrigerators and, if necessary, recommend that a separate, washable container be kept in the refrigerator to keep raw meats from contaminating ready-to-eat foods. Encourage the use of a refrigerator and cooking thermometer to make sure food is kept at appropriate temperatures.
- Ask about food preparation areas and techniques and also discuss the importance of using separate cutting boards. Help patients select appropriate cleaning products and stress the importance of cleaning food preparation surfaces frequently during meal preparation.
- Consider patients' different socioeconomic situations. For example, one of the recommendations in the food safety guidelines is that all produce items should be washed thoroughly, even those with a thick peel, before consumption. Determine whether an individual has access to fresh produce and clean water and has the ability to stand at the sink long enough to clean the produce. If this is problematic, it may be easier for some individuals to consume only canned or frozen fruits and vegetables.
- Also, determine whether individuals have the financial means to meet any recommendations being made. For example, before recommending that the individual drink only bottled water, consider whether the individual has the financial resources for this added expense.
- Determine whether people who are ill have meals brought into the home by friends and family members. Discuss ways that the patient can share food safety tips with these people to ensure safe food handling by all those involved in the patient's care. Provide brief, easy-to-read guidelines that families can share with those who are offering assistance. Discuss the importance of refrigerating leftovers as soon as possible and reheating them to 165° F to avoid any problems with bacterial growth/contamination.

### **Research Gaps and Current Questions**

There are many questions yet to be answered regarding the use of the neutropenic diet. As previously mentioned, most of the studies investigating the efficacy of the neutropenic diet are out of date and don't reflect newer medical practices. Gathering additional data would be helpful, but designing and implementing scientifically meaningful studies can be challenging due to the number of variables that must be controlled. For instance, it's difficult to randomize patients, especially those who are more acutely ill. It's also difficult to obtain larger sample sizes that help to stratify risk.



Neutropenic dietary practices have been used for more than 50 years, allowing for many variations and institutional practices to be created, thus reducing the ability to obtain accurate research study results. In addition, most hospitalized patients prescribed a neutropenic diet have other environmental precaution orders that confound study results. Implementation of multiple environmental precautions, such as requiring the patient to reside in a negative air flow room, requiring all staff and visitors to wear a protective gown, requiring the wearing of gloves and masks to reduce exposure to harmful microorganisms, make it difficult to determine which precaution reduced the risk of infection. Research that includes more information about how different institutions maintain this protective environment in coordination with safe dietary management may also help to create more standardization among institutions and offer more clarity on the most ideal and effective practices.

It's important to decrease the risk of malnutrition in neutropenic cancer patients, who potentially could suffer from multiple treatment-related side effects. Could neutropenic diet restrictions lead to involuntary weight loss, lengthened recovery time, and impaired healing? Future studies investigating the recovery time from treatment-related side effects and the degree of malnutrition while prescribed a neutropenic diet would provide further insight.

Investigating the risk of infection in neutropenic patients in the outpatient setting who have been educated on food safety guidelines vs neutropenic diet guidelines would provide useful data to help develop patient recommendations. Adherence to food safety guidelines rather than prescribing a restricted neutropenic diet would allow individuals to consume a varied diet high in nutrient-rich, plant-based foods as recommended for cancer survivors by leading cancer research organizations. It's known that a plant-based diet is one strategy for reducing cancer risk.<sup>27</sup> Frequently, individuals who have been diagnosed with cancer desire to make such lifestyle changes and wish to incorporate more plant-based foods into their diets.

In addition, because more patients are treated and followed in an outpatient setting, appropriate transition from an inpatient, infection-controlled environment, such as that used in bone marrow transplantation, to the outpatient setting is vital. Developing appropriate guidelines and educational strategies for patients and caregivers can ease the burden.

Continuous advances in modern cancer care have added to the controversy regarding the need for a neutropenic diet. Advances in colony-stimulating factor therapies used to increase neutrophil production, such as Neulasta and Neupogen, have decreased chemo-induced neutropenia and early deaths from infection.<sup>28</sup> The use of antimicrobial prophylaxis can reduce infection rate and mortality in neutropenic patients.<sup>29</sup> Further advancement in these treatments have the potential to further decrease the need for restrictive diets, allowing individuals to continue consuming diets that give them more freedom of choice.

There's a lack of research regarding many specific foods and their safety for neutropenic patients. For example, there is little published evidence on the safety of neutropenic oncology patients consuming probiotics in foods such as yogurt and buttermilk, or in supplemental form. Although there's concern about the bacterial translocation of the probiotics past the intestinal mucosa, probiotic use may decrease the risk of bacterial translocation in the gut and reduce the risk of febrile neutropenia.<sup>30</sup> A recent review article concluded that probiotic use may be

safe for cancer patients even in the setting of neutropenia, but data are limited and further studies need to be conducted.<sup>31</sup>

Sprouts, including alfalfa, bean, clover, and radish, should be avoided in healthy and immunocompromised individuals, as recommended by the FDA. If sprouts will be consumed, the agency recommends cooking them before eating. Growing methods haven't been developed that completely decontaminate raw sprouts.<sup>32</sup>

The safety of neutropenic patients consuming fresh and frozen berries has been a frequently discussed issue and evidence is lacking concerning the safety of doing so, warranting further investigation. For now, some RDs encourage neutropenic patients to avoid berries. Raspberries and other similar berries are difficult to clean because of their architecture and delicate structure, and imported raspberries have been linked to norovirus and cyclosporiasis infection in the past. However, evidence is lacking concerning the safety of consuming of fresh or frozen berries by the neutropenic population.

As practice continues to evolve and more institutions move away from older more restrictive practices, it will be a challenge to have staff “unlearn” old habits.

### **Recommendations**

When prescribing the neutropenic diet for people undergoing cancer treatment, their ability to adhere to the diet should always be taken into account. One study found that 43% of patients instructed to follow the neutropenic diet failed to do so.<sup>21</sup> Individuals undergoing cancer treatment typically have treatment side effects that interfere with their ability to consume their normal diets. Health care teams should monitor the individuals' weight and liberalize restrictions if involuntary weight loss becomes a problem. Moody and colleagues concluded that diet liberalization could improve food intake and quality of life.<sup>22</sup>

For those institutions that still practice more conservative dietary restrictions and wish to update their neutropenic diet policy, the inclusion of food safety guidelines for people with cancer is necessary. The only way to effectively and successfully implement a change in practice is to educate health care providers, especially focusing on those who may be resistant to change. Regardless, all individuals with cancer, with or without neutropenia, should be educated on food safety guidelines. The importance of following food safety guidelines will never become obsolete and should be reinforced for all patients.

Additional food safety information for patients and caregivers can be found by using the [USDA Meat and Poultry Hotline](#), the [FDA Food Information Line](#), and [www.askkaren.gov](http://www.askkaren.gov).

—Angela Hummel, MS, RDN, CSO, CDN, and Jessica Iannotta, MS, RDN, CSO, CDN, report the following relevant disclosure: both are consultants to Meals to Heal, a home meal delivery service for people with cancer and their caregivers. [View our disclosure policy](#).

[Click here](#) for patient handout “Safe Food Handling.”

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## Examination

**1. The National Cancer Institute defines severe neutropenia as an absolute neutrophil count:**

- A. Below 2,000/mm<sup>3</sup>
- B. Above 1,500/mm<sup>3</sup>
- C. Above 1,000/mm<sup>3</sup>
- D. Below 1,000/mm<sup>3</sup>

**2. Neutropenia is difficult to prevent in cancer patients receiving treatment for which of the following reasons?**

- A. Cancer treatments interfere with neutrophil production and life cycle.
- B. Neutrophils don't respond to growth factors.
- C. Cancer patients have poor immune systems.
- D. Cancer cells destroy white blood cells.

**3. When educating patients on food safety guidelines for the home environment, it is important to take into account which of the following? The patients'**

- A. Medical insurance
- B. Proximity to a supermarket
- C. Access to clean water
- D. Ability to tolerate raw produce

**4. Limitations in the research examining the role of diet in controlling infection risk are confounded by other environmental precautions including which of the following:**

- A. Patient rooms cleaned daily by hospital housekeeping staff
- B. The patients opening windows to allow fresh air in hospital quarters
- C. The patients receiving fresh linens and gowns daily
- D. The patients residing in negative air flow rooms, requiring all staff and visitors to wear a protective equipment

**5. Bacterial translocation occurs under which of the following circumstances?**

- A. When bacteria are ingested from contaminated food.
- B. When bacteria have passed through damaged intestinal mucosa to other sites within the body.
- C. When bacteria have contaminated produce from the soil.
- D. When bacteria have been consumed by animals and contaminated the meat supply.

**6. Studies have found that implementing a neutropenic diet decreases infection rates in neutropenic patients.**

- A. True
- B. False

**7. The FDA has created food safety guidelines for people with cancer. Which of the following are the four basic food safety steps?**

- A. Washing, storing, monitoring, preserving
- B. Cleaning, separating, cooking, chilling
- C. Tasting, smelling, feeling, observing
- D. Buying, storing, packaging, consuming

**8. Which of the following describes colony-stimulating factors?**

- A. They're an injectable form of neutrophils from a matched donor.
- B. They stimulate the appetite, which increases nutrient consumption and leads to better neutrophil production.
- C. They improve the production of neutrophils in the bone marrow.
- D. They inhibit the death of neutrophils from cancer treatment.

**9. The FDA considers the consumption of which of the following food items unsafe for all individuals?**

- A. Raw sprouts
- B. Fresh fruit and vegetables
- C. Probiotics
- D. Deli meat

**10. There's convincing evidence that probiotic use is safe for neutropenic patients.**

- A. True
- B. False