Based on surveillance data since 1999, it is estimated that each year pathogenic bacteria cause 9.4 million foodborne illnesses, 55,961 hospitalizations, and 1,351 deaths in the United States (1). The financial impact of foodborne illness in the United States is estimated—based on medical costs, productivity losses (pain, suffering, and functional disability), and mortality—to be $1,626 per case of illness with an aggregated annual cost of $77.7 billion annually (2). Between 2001 and 2010, the four food categories, namely, seafood, produce, poultry, and beef, were associated with 51% of all foodborne outbreaks and 25% of all foodborne illnesses. Among the four top categories, produce had the highest number of outbreaks (696 outbreaks with 17% of total outbreaks) and 25,222 illnesses (24% of total illnesses) (3). The produce commonly associated with outbreaks and illnesses were reported to be greens-based salads, lettuce, and sprouts. There were 27 E. coli outbreaks in green leafy vegetables including lettuce and spinach between 1998 and 2010 reported by the Centers for Disease Control and Prevention (CDC) (4). The most recent outbreak in August 2013 involved at least 646 people in 24 states being diagnosed with cyclospora infections, which has been linked to a fresh mixed salad source. Earlier in 2010, an E. coli O145 outbreak in romaine lettuce resulted in a total of 26 confirmed and 7 probable illnesses from 5 states leading to a recall in 23 states. A major outbreak in 2006 due to E. coli O157:H7 contamination in ready-to-eat bagged fresh spinach caused 3 deaths and 205 illnesses spread over 26 states (Figure 1). Although the source of the outbreak was traced to California, the outbreak-related cases were observed as far away as Maine and outside the United States in Ontario, Canada.

Leafy greens can be challenging to clean because of crevices and pores where bacteria can hide which may not be accessible by conventional sanitizers. Fresh produce can also be easily bruised and create areas that are more susceptible to microbial growth. According to a report released by the Center for Science in the Public Interest (CSPI) in October 2009, leafy greens were declared to be number one in the top ten riskiest foods regulated by the FDA (5). The leafy greens category includes iceberg lettuce, romaine lettuce, leaf lettuce, butter lettuce, baby leaf lettuce, escarole, endive, spring mix, spinach, cabbage, kale, arugula, and chard, which are mostly consumed fresh. CSPI maintains a Searchable Outbreak Alert Database, which was recently updated to include data from 2010 (6). Produce including fruits, vegetables, and dishes containing fruits or vegetables had 1,038 outbreaks and 43,858 associated illnesses between 1990 and 2010. Table 1 shows the outbreak and illness data for individual leafy greens we compiled from the CSPI database.

The increase in fresh produce related outbreaks may be attributed to the following factors:

1) **Increased outbreaks due to increased consumption:** Recent changes in consumer behavior toward more healthy and nutritious diets have led to increased consumption of fresh fruits and vegetables. The availability of ready-to-eat prepackaged fresh produce (since its first introduction to the market in 1989) has also contributed to the increased consumption of fresh produce.
fruits and vegetables. Ready-to-eat prepackaged fresh produce contributes to a healthy diet with convenience for today’s busy lifestyle. For example, total consumption of lettuce increased from 877 million pounds (3.5 lbs per capita) in 1985 to 3,270 million pounds (11 lbs per capita) in 2004 followed by a decrease to 2,858 million pounds (9 lbs per capita) in 2009 and is back on recovery to 3,110 million pounds (10 lbs per capita) in 2011 (Figure 2). This pattern of consumption followed the incidence of fresh produce-related outbreaks and illnesses. In response to outbreaks, the consumption of fresh produce decreased temporarily; as the outbreaks subsided, consumption started to increase again.

2) Outbreaks spread widely and quickly: An efficient distribution network is necessary for fresh produce because of the limited shelf life of these products. Prepackaged, ready-to-use fresh spinach has approximately two weeks of shelf life under refrigerated conditions between packaging and the date indicated on the package for the best use. The two-week period includes the time for transportation to and within the supermarket chain, on the supermarket shelf, and in the consumer’s refrigerator. This fast, efficient distribution chain to accommodate the short shelf life of fresh produce provides consumers the advantage of being able to access fresh produce almost as quickly as locally grown foods. However, in the case of an outbreak, the advantage turns into increased risk of wide distribution and rapid spread of illness. The increased consumption and the improved efficiency of delivery caused an increase in the frequency of multistate outbreaks between 1990 and 2011 (Figure 3).

3) Timely diagnosis of outbreak: The distribution of an outbreak over a large area makes it difficult to connect cases to each other and to trace back the problem to the original source. If the consumption occurs in a small area, the number of cases will be large enough to get attention and trigger investigation of the incident as a potential outbreak. CDC defines an outbreak as “two or more cases of the same disease related to a common exposure.” However, the spread of disease over a large area with fewer number of cases delays the action. In the case of the fresh spinach outbreak, although the first case was reported on August 2, 2006, a larger number of illness clusters were reported between August 25 and September 12, 2006 (25 cases on August 31, 2006). By the time the FDA issued “a spinach advisory” on September 14 and the firm issued a recall of product on September 15, 2006, the number of daily cases reported were reduced to one or two. The delay occurs not only due to the time it takes for the spread of illness

Table 1. Outbreak and illness caused by leafy greens, 1990–2010 (Source: CSPI)

<table>
<thead>
<tr>
<th>Produce Type</th>
<th>Number of Outbreaks</th>
<th>Number of Illnesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>75</td>
<td>2,772</td>
</tr>
<tr>
<td>Spinach</td>
<td>4</td>
<td>300</td>
</tr>
<tr>
<td>Basil</td>
<td>5</td>
<td>1,016</td>
</tr>
<tr>
<td>Cilantro</td>
<td>4</td>
<td>76</td>
</tr>
<tr>
<td>Green onion</td>
<td>9</td>
<td>1,221</td>
</tr>
<tr>
<td>Parsley</td>
<td>4</td>
<td>558</td>
</tr>
<tr>
<td>Salad</td>
<td>306</td>
<td>10,122</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>16,065</td>
</tr>
</tbody>
</table>

Figure 2. Consumption of lettuce, green dots, (7) lettuce-related outbreaks, blue bars, and lettuce-related illnesses, red bars, (3) compiled from USDA ERS and CSPI databases.

Figure 3. Frequency of lettuce-related outbreaks, blue bars, and multistate outbreaks, red bars, compiled from CSPI database (3).
but also because the timeline of events between the patient being infected and the patient being considered part of the outbreak. The timeline could be a minimum of 6 days to a maximum of 23 days including the time of incubation of bacteria in humans, seeking treatment, diagnosis, sample shipping to state public health authority, and “DNA fingerprinting” to determine the specific strain (Figure 4).

As outbreaks are diagnosed more efficiently, the apparent number of official outbreaks may increase; however, they can be intercepted, preventing a large spread and reducing the number of illnesses.

These issues discussed in detail suggest that increased consumption of fresh ready-to-eat produce may be a partial cause of the increased outbreaks. Currently, identifying any outbreak may take, on average, 2 weeks. Therefore, it is important that all efforts by processors, distributors, retailers, government and consumers be directed toward prevention of foodborne illness outbreaks. Prevention of outbreaks and costly recalls can be achieved by improving the current practices employed for processing fresh produce.

![Figure 4. Timeline of outbreak confirmation. Source: National Center for Infectious Diseases (8).](image)

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