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Quantitative Data Analysis To Determine Best Food Cooling Practices in U.S. Restaurants†

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ABSTRACT

Data collected by the Centers for Disease Control and Prevention (CDC) show that improper cooling practices contributed to more than 500 foodborne illness outbreaks associated with restaurants or delis in the United States between 1998 and 2008. CDC's Environmental Health Specialists Network (EHS-Net) personnel collected data in approximately 50 randomly selected restaurants in nine EHS-Net sites in 2009 to 2010 and measured the temperatures of cooling food at the beginning and the end of the observation period. Those beginning and ending points were used to estimate cooling rates. The most common cooling method was refrigeration, used in 48% of cooling steps. Other cooling methods included ice baths (19%), room-temperature cooling (17%), ice-wand cooling (7%), and adding ice or frozen food to the cooling food as an ingredient (2%). Sixty-five percent of cooling observations had an estimated cooling rate that was compliant with the 2009 Food and Drug Administration Food Code guideline (cooling to 41°F [5°C] in 6 h). Large cuts of meat and stews had the slowest overall estimated cooling rate, approximately equal to that specified in the Food Code guideline. Pasta and noodles were the fastest cooling foods, with a cooling time of just over 2 h. Foods not being actively monitored by food workers were more than twice as likely to cool more slowly than recommended in the Food Code guideline. Food stored at a depth greater than 7.6 cm (3 in.) was twice as likely to cool more slowly than specified in the Food Code guideline. Unventilated cooling foods were almost twice as likely to cool more slowly than specified in the Food Code guideline. Our data suggest that several best cooling practices can contribute to a proper cooling process. Inspectors unable to assess the full cooling process should consider assessing specific cooling practices as an alternative. Future research could validate our estimation method and study the effect of specific practices on the full cooling process.

Improper cooling of hot foods by restaurants is a significant cause of foodborne illness in the United States. Data collected by the Centers for Disease Control and Prevention (CDC) show that improper cooling practices contributed to 504 foodborne illness outbreaks associated with restaurants or delis between 1998 and 2008 *(1)*.

Clostridium perfringens is the pathogen most frequently associated with foodborne illness outbreaks caused by improper cooling of foods. Between 1998 and 2002, 50 (almost 50%) of 102 outbreaks with known etiologies associated with improper cooling were caused by *C. perfringens (7)*. *C. perfringens* spores can germinate during cooking, and the resulting cells grow quickly, especially when foods are cooled too slowly. *Bacillus cereus* spores can also survive the cooking process and may pose a risk during improper cooling *(7)*. The U.S. Food and Drug Administration (FDA) Food Code provides the basis for state and local codes that regulate retail food service in the United States and contains cooling guidelines for food service establishments. To combat foodborne illness outbreaks associated with improper cooling, the 2009 FDA Food Code (section 3-501.14) states that cooked foods requiring time-temperature control should be cooled ''rapidly'' (specifically from 135 to 70°F [57 to 21°C]) within ≤2 h, and cooled further from 70 to 41°F (21 to 5°C) within an additional ≤4 h *(14)*. The U.S. Department of Agriculture (USDA) Food Safety Inspection Service (FSIS) has similar cooling requirements for commercially processed cooked meats. These requirements state that the maximum internal temperature of cooked meat should be allowed to remain between 130 and 80°F (54.4 and 26.7°C) for no longer than 1.5 h and then between 80 and 40°F (26.7 and 4.4°C) for no longer than an additional 5 h *(12)*.

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† This publication is based on data collected and provided by the Centers for Disease Control and Prevention's (CDC) Environmental Health Specialists Network (EHS-Net). The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the CDC/the Agency for Toxic Substances and Disease Registry.

The Food Code also recommends specific methods to facilitate cooling. Some of these methods include placing food in shallow pans, refrigerating at the maximum cold-holding temperature of 41°F (5°C), and ventilating (i.e., keeping food uncovered or loosely covered) to facilitate heat transfer from the surface of the food. The Food Code also recommends that the person in charge of the food service establishment (e.g., manager) ensure that workers routinely monitor food temperature during cooling *(13)*.

Little is known about how restaurants cool food, and yet knowledge about these issues is essential to developing effective cooling interventions. Thus, during 2009 to 2010, the CDC's Environmental Health Specialists Network (EHS-Net), a group of environmental health specialists and epidemiologists focused on investigating environmental factors that contribute to foodborne illness, conducted a study designed to describe restaurants' food cooling practices and to assess the effectiveness of these practices.

This work is the second arising from this cooling study. In the first article, we presented descriptive data on restaurant cooling practices *(1)*. In this second article, we present additional quantitative analysis to determine practices that best ensure a proper cooling process. Specifically, we examine how food type, active food temperature monitoring, food pan depth, and food ventilation are related to estimated food cooling rates.

MATERIALS AND METHODS

EHS-Net, a collaborative program of the CDC, FDA, USDA, and state and local health departments, conducted this study in collaboration with Rutgers University. At the time this study was conducted, nine state and local health departments were funded by the CDC to participate in EHS-Net. These state and local health departments, or EHS-Net sites, were in California, Connecticut, New York, Georgia, Iowa, Minnesota, Oregon, Rhode Island, and Tennessee.

Personnel in each of the nine EHS-Net sites collected the data for this study. These data collectors visited approximately 50 randomly selected restaurants in each of the nine EHS-Net sites. Restaurant visits lasted an average of 80 min. Information on data-collection training, Institutional Review Board status, and sample selection for this study is available in a previous publication based on this study *(1)*. In brief, standardized data collection forms, developed by the CDC and EHS-Net site staff, were used. Forms were piloted by EHS-Net data collectors, and revisions were made based on the pilot results. Data collectors also participated in training designed to increase data collection consistency. This training included a written restaurant cooling scenario that data collectors reviewed as a group to ensure consistent interpretation and coding. These personnel were environmental health specialists, experienced and knowledgeable in food safety.

In each restaurant participating in the study, data collectors interviewed a kitchen manager about restaurant characteristics and cooling policies and practices. If food was being cooled during their visit to the restaurant, data collectors also recorded observational data on cooling practices. Data collectors recorded data on the types of food being cooled, the number of steps involved in the cooling process, and the method used in each cooling step to cool the food (refrigeration [keeping food at or below 41°F (5°C)], ice bath, ice wand, blast chiller, adding ice or frozen food as an ingredient, room-temperature cooling). Data collectors recorded additional observational data on the details of the refrigeration methods, such as whether the food depth was shallow (defined for this study as ≤7.6 cm [3 in.] deep), whether the food was ventilated (i.e., uncovered or loosely covered), and what the cooling environment temperature was.

Data collectors also recorded whether workers monitored the time or temperature of the cooling foods during the observation period. Worker monitoring actions included taking the temperature of the food with a probe or data-logging thermometer, using a timer or alarm to measure cooling time, or noting food cooling time with a clock.

Data collectors also measured the temperatures of cooling foods at the beginning and end of the observation period by inserting calibrated thermometers into the centermost point of the foods. Those beginning- and ending-point temperatures were taken in similar places in the food and were used to estimate cooling rates according to the procedure outlined in the following text. All data collectors used digital probe thermometers to measure temperatures, and they calibrated their thermometers regularly. Additionally, the method of taking each temperature was specified in the data collection protocol. For example, data collectors were instructed to take the temperature of cooling food at the centermost area of the food. Data collectors used different brands of thermometers.

When foods are cooled in accordance with either the FDA Food Code or the USDA FSIS guidelines, the required change in temperature is nonlinear with respect to time *(10)*. Such nonlinear temperature profiles are also typically observed in practice due to the physical principles that govern cooling. At the start of a cooling process, a large temperature differential, often called the driving force, exists between the food and the cooling environment. A large driving force means a rapid cooling rate. As a food cools, the driving force lessens—a smaller driving force means a slower cooling rate.

Although temperature profiles during cooling are nonlinear, the logarithm of the driving force is linear with time; therefore, cooling rates can be estimated from the beginning and ending points recorded by the data collectors. Thus, the estimated cooling rate as shown by Smith-Simpson and Schaffner *(9)* was assumed to be $[\mathrm{Log}(T_1 - T_{\mathrm{df}}) - \mathrm{Log}(T_2 - T_{\mathrm{df}})]/t$. T_1 and T_2 are the two temperatures measured during cooling, T_{df} is the driving force temperature, i.e., the temperature of the cooling environment, and t is the time between the two temperature measurements.

If we consider the cooling profile recommended in the 2009 FDA Food Code (from 135 to 70°F [57.2 to 21.1°C] in 2 h, from 70 to 41°F [21.1 to 5°C] in an additional 4 h), assume a driving force temperature of 37°F (2.8°C), and perform simple linear regression, the equation that matches the FDA Food Code cooling profile is $\mathrm{Log}(\Delta T) = -0.2312t + 1.9871$. ΔT is the difference between the food temperature and the driving force temperature, 37°F (2.8°C) in this case, and t is the cooling time in h. Although any driving force could be assumed, the driving force that converts the cooling profile recommended in the Food Code (135 to 70°F [57 to 21°C] in 2 h and 70 to 41°F [21 to 5°C] in an additional 4 h) to the straightest possible line (i.e., $R^2 = 0.99994$) is achieved when a driving force temperature of 37°F (2.8°C) is used. Note than 37°F (2.8°C) is actually a more sensible assumption of a driving force when refrigeration is used because, for a food to actually reach 41°F (5°C), the driving force must be less than 41°F [5°C]. Because the data collectors also recorded the environmental temperature (i.e., the driving force temperature, T_{df}), this actual value was used to calculate the cooling rate. When cooling with a different method was used, a different driving force temperature was used (e.g., room temperature cooling would be a 70°F [21.1°C] driving force temperature, and ice wand or ice bath cooling would be a 32°F [0°C] driving force temperature).

The slope of the cooling profile is the coefficient 0.2312 in the previous equation, so any food cooled at this rate can be assumed to comply with the FDA Food Code (i.e., cooling from 135°F [57.2°C] to 41°F [5°C] within 6 h). Foods cooled at a faster rate (>0.2312) cool faster than recommended in the Food Code guidelines, and foods cooled at a slower rate (<0.2312) cool slower than recommended in the Food Code guidelines. This approach does involve making the assumptions that the estimated cooling rate follows the earlier equation and can be predicted using only two points. However, an alternative approach, calling for more temperature measurements during the cooling process, would have required data collectors to be present in the restaurants for a longer period than was feasible. Cooling rate distributions were created using the histogram function of the Data Analysis ToolPak in Excel (Microsoft, Redmond, WA).

RESULTS

Restaurant sample. As noted by Brown et al. *(1),* 420 restaurant managers agreed to participate in the study, a participation rate of 68.4%. According to manager interview data, 290 (69%) of restaurants in the study were independently owned; the remaining 130 (31%) were chain restaurants. Most restaurants (252 [60%]) served an American menu, 47 (11%) served Italian, 34 (8%) Mexican, 21 (5%) Chinese, and 66 (16%) ''other.'' The median number of meals served daily was 150; the numbers of meals served daily ranged from 7 to 7,700.

Food cooling observation. As noted in Brown et al. *(1),* data collectors observed 596 food items being cooled during their visits in 410 restaurants. Soups, stews, and chilis were the most common food items being cooled (178 [30%]), followed by poultry and meat (150 [25%]), sauces and gravies (92 [15%]), cooked vegetables (40 [7%]), rice (34 [6%]), beans (31 [5%]), pasta (23 [4%]), casseroles (19 [3%]), seafood (7 [1%]), pudding (6 [1%]), and other foods (16 [3%]). Data collectors observed 1,070 steps used during the cooling of these food items. Because one food might be cooled by at least one step, and by as many as four different steps, the number of steps exceeded the number of foods. The most common cooling method was refrigeration, used in 511 (48%) of the cooling steps. Other cooling methods included ice baths (199 [19%]), room-temperature cooling (182 [17%]), ice-wand cooling (80 [7%]), adding ice or frozen food to the cooling food as an ingredient (27 [2%]), blast chillers (5 [<1%]), and other methods (66 [6%]).

Extraction of EHS-Net data. To determine the overall distribution of estimated cooling rates, we used data from cooling step observations that met key criteria for our analysis. The key criteria required for each cooling step observation were a starting temperature, an ending temperature, the elapsed time between the starting and ending temperature, and the driving force temperature (cooling environment temperature). More than 1,000 (1,014) cooling step observations from the EHS-Net data set met these criteria. For each of these step observations, an estimated cooling rate was calculated using the methods and equations described earlier. We used the same process to examine how food type and active food temperature monitoring by food workers affected estimated cooling rate. Nine hundred thirty (930) step observations had data on food type and 1,014 observations had data on cooling method. Cooling steps involving refrigeration (453) also had data on food depth and ventilation during refrigeration; these data were analyzed further.

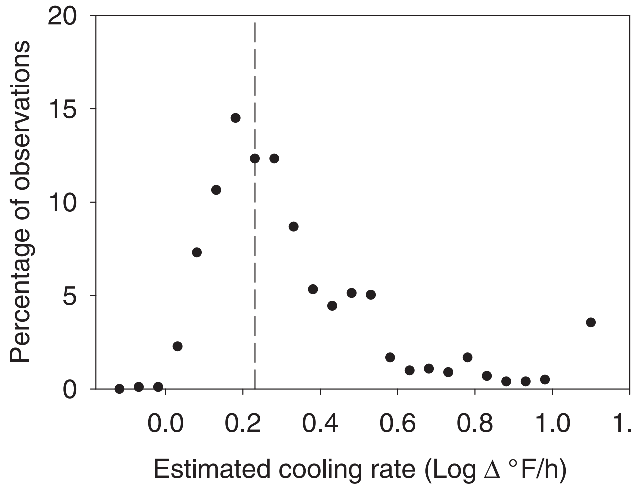

FIGURE 1. *Frequency distribution of estimated cooling rates of 1,014 observations of cooling food. Food Code cooling rate is 0.23 (cooling to 41°F [5°C] within 6 h), indicated by the dotted vertical line.*

Estimated cooling rates. Figure 1 shows the overall distribution of estimated cooling rates, based on beginning- and ending-point food temperatures taken by the data collectors. The *x* axis represents the estimated cooling rate, and the *y* axis represents the fraction of the number of times a particular estimated cooling rate was observed. The vertical line indicates the Food Code guideline cooling rate of ~0.23 (cooling to 41°F [5°C] in 6 h). Cooling step observations positioned left of this line represent foods that were cooling at rates slower than the Food Code guideline. Observations positioned right of this line represent foods that were cooling at rates as fast as or faster than the Food Code guideline. Of the observations, 660 (65%) had an estimated cooling rate that was as fast as or faster than the Food Code guideline. In 36 (~3%) observations there was a very rapid estimated cooling rate (rate of >1, cooling to 41°F [5°C] faster than 1.4 h). Conversely, 354 (~35%) observations had an estimated cooling rate slower than the Food Code guideline. One hundred forty-seven (almost 15%) observations had an estimated cooling rate that was only slightly slower than the Food Code guideline (rate of ~0.18, cooling to 41°F [5°C] in 7.7 h); this was the most frequently observed cooling rate. In 108 (~10%) of the observations, the estimated cooling rate was significantly slower than the Food Code guideline (rate of 0.13, cooling to 41°F [5°C] in 10.7 h). In 9% of observations, the estimated cooling rate was slower than 0.13 (in 74 [7%], rate of 0.08 [cooling to 41°F (5°C) in 17.4 h]; in 23 [2%], rate of 0.03 [cooling to 41°F (5°C) in >24 h]). Finally, two observations showed an estimated cooling rate of less than 0

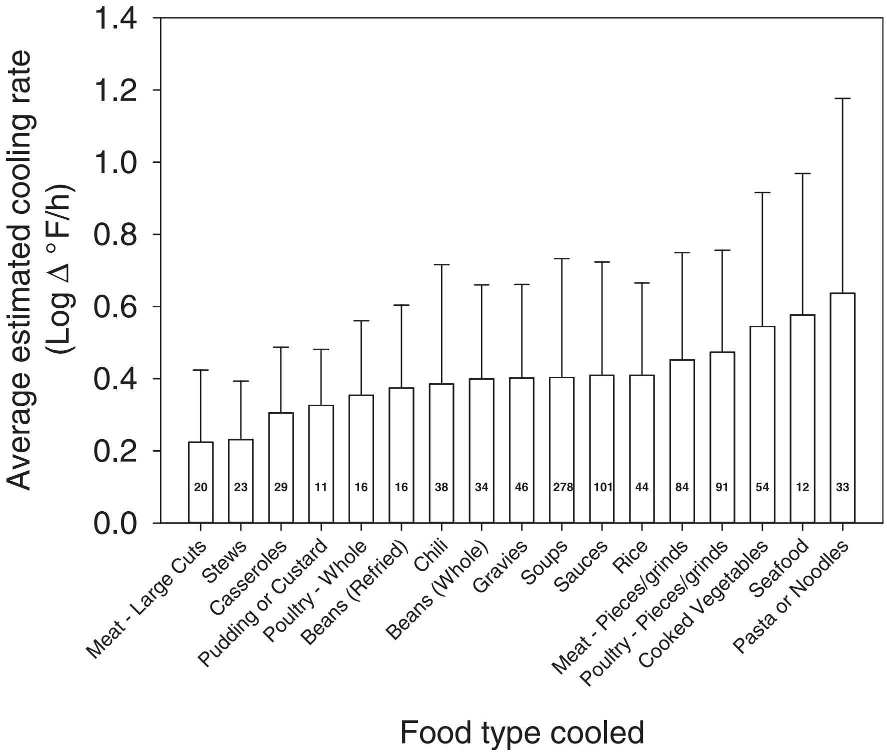

FIGURE 2. *Relationship between food type and the average estimated cooling rate. Food Code cooling rate is 0.23 (cooling to 41°F [5°C] within 6 h). Error bars represent the standard deviation of the cooling rate, and numbers superimposed on the bars represent the number of times each cooling rate was observed.*

(i.e., cooling attempts were made, but the temperatures actually increased slightly).

Estimated cooling rates and food type. Figure 2 shows the relationship between food type and the average estimated cooling rate. The *x* axis represents the food type for the cooling step observations, and the *y* axis represents the average estimated cooling rate; the standard deviation of the estimated cooling rate is shown as error bars. The numbers superimposed on the bars indicate the number of observations associated with each estimated cooling rate. Large cuts of meat and stews (in which *C. perfringens* presents a risk) show the slowest overall estimated cooling rate, a rate approximately equal to the Food Code guideline (rate of 0.23, cooling to 41°F [5°C] in 6 h). Pasta and noodles (in which *B. cereus* poses the primary risk) were the fastest cooling foods, with an average cooling rate of 0.64, which corresponds to a cooling time of just over 2 h. The large standard deviations show the high variability associated with each food type. Faster cooling rates (e.g., with pasta) were more often associated with higher variability, but even the slowest rates had high variability. Although some of these food types have pH values sufficient to prevent the growth of spore-forming bacteria, pH is seldom used as a control measure in restaurants. In addition, pH data on the products in question were not available.

Estimated cooling rates and time or temperature monitoring. Figure 3 shows the effect of monitoring of cooling food time or temperature by food workers on estimated cooling rates. The *x* axis represents the estimated cooling rate for the cooling step observations and the *y* axis represents the fraction of the time (expressed as a percentage) that this particular rate was observed for each condition (monitored and unmonitored). The vertical line indicates the Food Code guideline cooling rate of ~0.23. Closed circles indicate estimated cooling rates for foods that were monitored; open circles indicate estimated cooling rates for foods that were unmonitored. For estimated cooling rates that were slower than the Food Code guideline (positioned left of vertical line), unmonitored cooling was twice as common as monitored cooling. For estimated cooling rates that were slightly faster than the Food Code guideline (rate of 0.3, positioned slightly right of the dotted line, cooling to 41°F [5°C] in 4.6 h), monitored cooling was twice as common as unmonitored cooling. For faster cooling rates (rate of 0.4 and higher, cooling to 41°F [5°C] in 3.5 h and faster) there was little difference between monitored and unmonitored cooling. Considering all the data together, unmonitored food is more than twice as likely (2.2 times) to cool slower than the Food Code guideline.

Estimated cooling rates and food depth. Figure 4 shows how food depth affects estimated cooling rates. The *x* axis represents the estimated cooling rate for the cooling step observations, and the *y* axis represents the frequency of the estimated cooling rates. The vertical line indicates the Food Code guideline cooling rate of ~0.23. Closed circles indicate estimated cooling rates for foods that were ≤7.6 cm (3 in.) deep in containers; open circles indicate estimated cooling rates for foods that were >7.6 cm (3 in.) deep. For estimated cooling rates that were slower than the Food Code guideline (i.e., positioned left of the dotted line), cooling in deep pans was observed about twice as often as cooling in shallow pans. For estimated cooling rates that were as fast as or faster than the Food Code guideline (i.e., positioned right of the dotted line), shallow food depths were generally observed more frequently than deep food depths. Considering

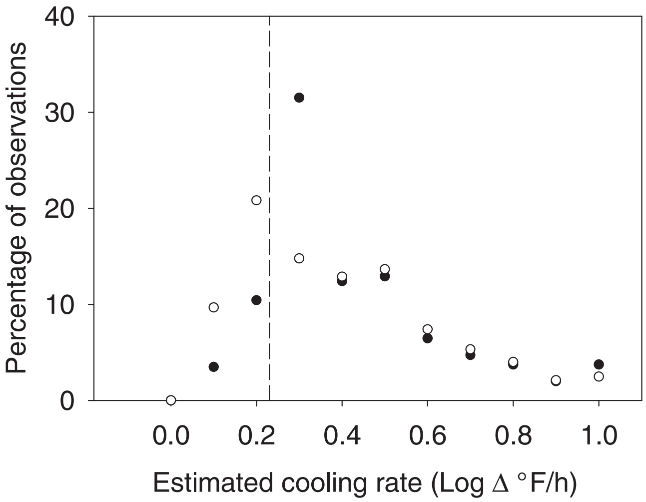

FIGURE 3. *Effect of active temperature monitoring by food workers and estimated cooling rate. Closed circles indicate cooling rates for monitored food; open circles indicate cooling rates for unmonitored food. Food Code cooling rate is 0.23 (cooling to 41°F [5°C] within 6 h), indicated by the dotted vertical line.*

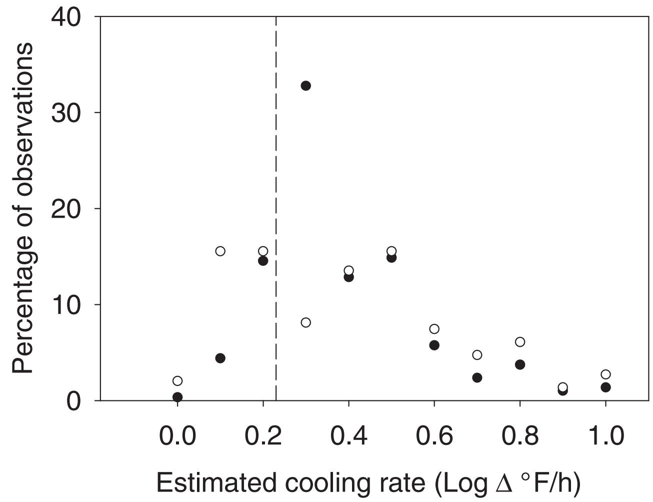

FIGURE 5. *Effect of ventilation on estimated cooling rate. Closed circles indicate ventilated food cooling rates; open circles indicate unventilated food cooling rates. Food Code cooling rate is 0.23 (cooling to 41°F [5°C] within 6 h), indicated by the dotted vertical line.*

all the data together, food deeper than 7.6 cm (3 in.) in containers is twice as likely to cool slower than the Food Code guideline.

Estimated cooling rates and ventilation. Figure 5 shows how ventilation affects the estimated cooling rate. The *x* axis represents the estimated cooling rate for the cooling step observations, and the *y* axis represents the frequency of the estimated cooling rates. The vertical line indicates the Food Code guideline cooling rate of ~0.23. Closed circles indicate ventilated food cooling rates; open circles indicate unventilated food cooling rates. For estimated cooling rates that were much slower than the Food Code guideline (rate of 0.1, cooling to 41°F [5°C] in ~14 h), unventilated cooling was observed more than three times as often as ventilated cooling. When estimated cooling rates were slightly slower than the Food Code guideline (rate of 0.2, cooling to 41°F [5°C] in ~7 h), the frequency of ventilated and unventilated cooling was similar. For estimated cooling rates that were slightly faster than the Model Food Code (rate of 0.3, cooling to 41°F [5°C] in 4.6 h), ventilated cooling was observed more than four times as often as unventilated cooling. Considering all the data together, unventilated cooling foods were almost twice (1.7 times) as likely to cool slower than the Food Code guideline.

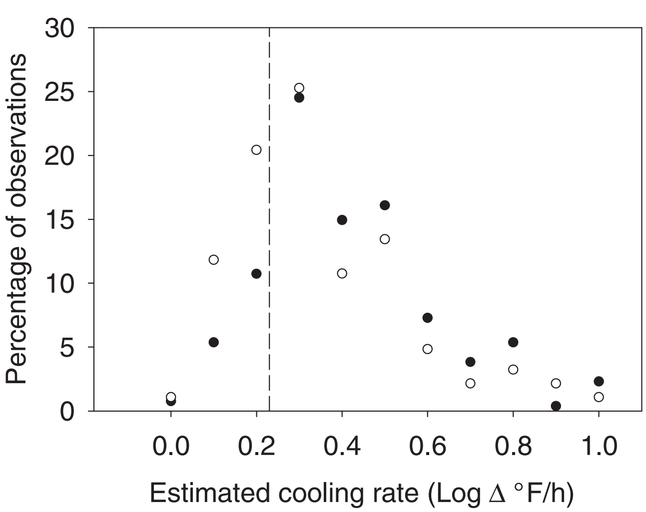

FIGURE 4. *Effect of food depth on estimated cooling rate. Cooling rates for food in shallow pans (≤3 in. [7.6 cm] deep) indicated by closed circles; cooling rates for food in deep pans (>3 in. [7.6 cm] deep) indicated by open circles. Food Code cooling rate is 0.23 (cooling to 41°F [5°C] within 6 h), indicated by the dotted vertical line.*

DISCUSSION

The data from this study indicate that about a third of restaurant cooling step observations had an estimated cooling rate that was slower than the Food Code guideline. These data are concerning because slow cooling can cause foodborne illness outbreaks *(5)*. However, many of these observations showed an estimated cooling rate that was only slightly slower than the Food Code guideline, which suggests that many restaurants may need to make only small changes to their cooling practices to comply with the Food Code guideline.

The data from this study indicate that following the Food Code guidelines concerning the cooling methods examined in this study likely will improve cooling rates and ensure compliance with Food Code guidelines. Following the Food Code guidelines (storing foods at shallow depths, ventilating foods, and actively monitoring cooling food time or temperatures) facilitated faster estimated cooling rates. Our data show that, of the three methods, active monitoring was the most effective (2.2 times more likely to meet Food Code guidelines), followed by shallow food depth (2 times more likely), and ventilation (1.7 times more likely).

Restaurants should be able to boost their cooling rates relatively easily by using one or more of these methods.

The data from this study also show that some foods, particularly large cuts of meat, are harder to cool to the Food Code guideline than other types of foods. These data are not surprising; other researchers have found similar results *(6, 11)*. These data reinforce the need for restaurants to pay particular attention to cooling these types of foods. The data from this study also confirm the difficulties of cooling food stored in deep containers; this circumstance is known to increase the risk of *C. perfringens* proliferation *(2–4)*.

This study is one of few to examine restaurant food cooling practices and processes. This lack of data may stem from the fact that assessing the full 6-h cooling process is time intensive and, thus, difficult to accomplish. The FDA attempted to assess restaurant food cooling processes in their Retail Risk Factor Study but encountered difficulties *(15)*. In that study, cooling was observed in substantially fewer retail establishments than were other food preparation practices, due, in part, to the limited amount of time data collectors had available to spend in establishments.

A limitation of this study is that it included only restaurants with English-speaking managers. Additionally, the data collected were susceptible to reactivity bias (as in any study involving observational activities). For example, food workers were aware that they were being observed and might have reacted to being observed by changing their routine behavior (e.g., monitoring cooling food temperatures more frequently).

Our study did not assess the full cooling process but instead used mathematic modeling to estimate cooling rates. The method, of necessity, had to assume that driving force temperature was constant, and at the single value measured by the data collectors, as explained in the methods above. Our data suggest that several best cooling practices can contribute to a process in which food is cooled properly. Future research could not only validate our estimation method but also further investigate the effect of specific cooling practices on the full cooling process.

It may be useful to frame the findings from this study in terms of contributing factors and environmental antecedents to foodborne illness outbreaks *(8)*. Contributing factors are factors in the environment that cause, or contribute to, an outbreak; environmental antecedents are factors in the environment that lead to the occurrence of contributing factors. In this case, slow or improper cooling is a contributing factor. Cooling practices such as storage of food in deep containers, lack of ventilation, and lack of active monitoring can be environmental antecedents to this contributing factor. Our data suggest that focusing on these environmental antecedents may help reduce outbreaks caused by slow or improper cooling.

Environmental health specialists who are not able to assess the full cooling process during their restaurant inspections may wish to consider assessing the specific cooling practices used in the cooling process (i.e., the environmental antecedents [e.g., food depth]), because these practices can be assessed far more quickly than can the full cooling process. This assessment will allow environmental health specialists to identify methods to improve the cooling process and educate restaurant managers accordingly. Our data suggest that, in many cases, the changes needed to improve the cooling process may be small and relatively easy to implement.

REFERENCES

1. Brown, L. G., D. Ripley, H. Blade, D. Reimann, K. Everstine, D. Nicholas, J. Egan, N. Koktavy, and D. N. Quilliam. 2012. Restaurant food cooling practices. *J. Food Prot.* 75:2172–2178.
2. Cevallos-Cevallos, J. M., E. D. Akins, L. M. Friedrich, M. D. Danyluk, and A. H. Simonne. 2012. Growth of *Clostridium perfringens* during cooling of refried beans. *J. Food Prot.* 75:1783–1790.
3. de Jong, A. E. I., R. R. Beumer, and M. H. Zwietering. 2005. Modeling growth of *Clostridium perfringens* in pea soup during cooling. *Risk Anal.* 25:61–73.
4. de Jong, A. E. I., F. M. Rombouts, and R. R. Beumer. 2004. Effect of cooling on *Clostridium perfringens* in pea soup. *J. Food Prot.* 67: 352–356.
5. Gould, L. H., I. Rosenblum, D. Nicholas, Q. Phan, and T. F. Jones. 2013. Contributing factors in restaurant-associated foodborne disease outbreaks, FoodNet sites, 2006 and 2007. *J. Food Prot.* 76:1824–1828.
6. Le Marc, Y., J. Plowman, C. F. Aldus, M. Munoz-Cuevas, J. Baranyi, and M. W. Peck. 2008. Modelling the growth of *Clostridium perfringens* during the cooling of bulk meat. *Int. J. Food Microbiol.* 128:41–50.
7. Lynch, M., J. Painter, R. Woodruff, and C. Braden. 2006. Surveillance for foodborne-disease outbreaks—United States, 1998–2002. *Morb. Mortal. Wkly. Rep.* 55:1–48.
8. Selman, C., and J. Guzewich. 2013. Environmental assessment in outbreak investigations, p. 98–106. *In* Y. Motarjemi, G. Moy, and E. Todd (ed.), Encyclopedia of food safety, vol. 4. Academic Press, Waltham, MA.
9. Smith-Simpson, S., and D. W. Schaffner. 2005. Development of a model to predict growth of *Clostridium perfringens* in cooked beef during cooling. *J. Food Prot.* 68:336–341.
10. Snyder, O. P. 1999. The basics of cooling food. Available at: http://www.hi-tm.com/Documents/Basic-cool.html. Accessed 20 February 2014.
11. Taormina, P. J., and W. J. Dorsa. 2004. Growth potential of *Clostridium perfringens* during cooling of cooked meats. *J. Food Prot.* 67:1537–1547.
12. U.S. Department of Agriculture, Food Safety and Inspection Service. 1999. Appendix B, Compliance guidelines for cooling heat-treated meat and poultry products (stabilization). Available at: http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/95-033F/95-033F_Appendix%20B.htm. Accessed 20 February 2014.
13. U.S. Food and Drug Administration. 2009. Chap. 2—Management and personnel, part 2-1—Supervision. *In* FDA Food Code 2009. Available at: http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/ucm181242.htm. Accessed 20 February 2014.
14. U.S. Food and Drug Administration. 2009. Chap. 3—Food, part 3-5—Limitation of growth of organisms of public health concern. *In* FDA Food Code 2009. Available at: http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/ucm186451.htm#part3-5. Accessed 20 February 2014.
15. U.S. Food and Drug Administration. 2009. FDA report on the occurrence of foodborne illness risk factors in selected institutional foodservice, restaurant, and retail food store facility types. Available at: http://www.fda.gov/downloads/Food/GuidanceRegulation/RetailFoodProtection/FoodborneIllnessRiskFactorReduction/UCM224682.pdf. Accessed 20 February 2014.