

Original Research

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Nationwide Preparedness Exercise Revealed Variation in Readiness for Outbreak Investigation in Environmental Health Units in Finland, 2020

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Abstract

Objectives: The aim was to characterize reported food- and waterborne outbreaks in Finland, 2010–2020, and to test local investigation teams' preparedness to investigate outbreaks.

Methods: The outbreaks reported to the Finnish registry for food and waterborne outbreaks were characterized by the number of outbreaks and people fallen ill, and the causative agent. Local investigation teams' measures and their timeliness in a simulated time-constrained case study were scored and analyzed descriptively.

Results: In 537 outbreaks, 12 399 fell ill and 19 (0.15%) died. The causative agent remained unknown in 218 outbreaks. The local investigation teams' median preparedness score was 15/29 (range 9–23) and the score differed markedly within regions. Differences in the speed of communication and the number of channels used were observed between the teams.

Conclusions: Differences between environmental health units' scores indicated inconsistency in outbreak investigations between areas in Finland. The variability in preparedness scores was high in both the highest and lowest outbreak incidence regions. Because outbreaks occur rarely in most EHU areas, preparedness exercises are necessary to maintain investigation skills. Measures to enhance sampling would be needed because the causative agent was unknown in over 1/3 of the outbreaks. Many local investigation teams lack experience in public communication and training on communicating about outbreaks is needed.

Foodborne diseases are a major public health concern all over the world.¹ They cause a significant burden of disease and mortality as well as a socioeconomic impact by loading the health care system and damaging trade.² Annually, an estimated 1 in 10 people fall ill with diarrheal disease after eating contaminated food.¹ Food can become contaminated at any stage of the production, delivery, or consumption chain as a result of environmental contamination, unsafe storage, or processing. International trade and complex food chains increase the risk of contaminated food products being distributed across national borders.³

In 2020, 3086 foodborne outbreaks resulting in 20 017 cases of illness were reported in the European Union (EU).⁴ The reporting rate varied widely between EU countries, from less than 0.1 to 12 outbreaks per 100 000 inhabitants. The variation in the reporting rate can be due to differences in the true numbers of outbreaks, but it may also reflect the ability to recognize outbreaks.⁵ The capacity to identify and manage outbreaks can be enhanced by appropriate preparedness measures. Public health preparedness includes precautionary measures to manage health emergencies.⁶ Preparedness exercises aim to validate and improve preparedness plans by reviewing and testing procedures and operational plans in use. For effective prevention of foodborne diseases, multidisciplinary collaboration including health and environmental health authorities is essential.^{5,7}

The aim of this study was to characterize foodborne outbreaks reported to the Finnish registry for food and waterborne outbreaks in 2010–2020, and to test the preparedness of the local investigation teams in a simulated time-constrained case study. The results can be used to assess the strengths and areas for improvement in the preparedness of foodborne outbreak investigation.

Methods

Surveillance of Food and Waterborne Outbreaks

In Finland, the Finnish Institute for Health and Welfare and the Finnish Food Authority, the municipal health and environmental health authorities, are responsible for investigating foodborne outbreaks.⁸ The municipal environmental health units (EHUs) aim to reduce, eliminate, and prevent environmental health risks and promote the health and well-being of people and

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animals. EHUs tasks include food control, health protection, and veterinary care. The municipal food control, health protection, and infectious disease authorities are responsible for the preparedness of food- and waterborne outbreak investigations as a team. After an outbreak investigation, the investigation team is obliged to report the findings to the online registry for food and waterborne outbreaks maintained by the Finnish Food Authority and the Finnish Institute for Health and Welfare.⁸ The number of outbreaks, the number of people who fell ill, and the causative agents reported to the Finnish registry for food and waterborne outbreaks in 2010–2020 were analyzed.

Preparedness Exercise Set-up

A scenario was designed to test the ability of the investigation teams to respond to food- and waterborne outbreaks and encouraged the participants to act as they would in a real situation. During 1 week, the municipal environmental health units (EHUs) were provided with case-related information daily as the exercise progressed (Table 1). The timing and frequency of case-related information delivery was not announced in advance, and no contacts and measures directed outside the EHUs were undertaken. The EHUs reported on the measures taken to identify and control the outbreak and responded to a survey afterwards on the usefulness of the exercise via an electronic survey tool (Webropol Oy, Finland). The response options for the statements in the survey were strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5), and the results were expressed as means.

The measures and the timeliness of the measures (Table 2) were scored and the survey data analyzed descriptively. Kendall's rank

correlation coefficient was used to calculate the correlation between preparedness scores and the EHU's resources. Linear regression analysis was used to estimate the association between the regional median preparedness score and the regional incidence of outbreaks.

Results

Notifications to the Finnish Registry for Food and Waterborne Outbreaks

In 2010–2020, 537 (mean 49 and range 36–75/year; mean incidence 0.88/100 000) food- or waterborne outbreaks were reported (Figure 1). The mean yearly incidence of outbreak reporting was highest in Southern Finland (1.1/100 000) and lowest in South-western Finland (0.4/100 000), while in Western and Inland Finland, Lapland, Eastern, and Northern Finland, the incidences were 0.9, 0.8, 0.7, and 0.6/100 000, respectively. Of the outbreaks, the majority were foodborne (500; 98%). In the outbreaks, 12 399 (range 564–1947/year) cases of illness (Figure 1) and 19 (case fatality rate 0.15%) deaths were identified.

The causative agent remained unknown in over 1/3 (218; 41%) of the outbreaks (Figure 2).

The most identified causative agent was norovirus (175; 33%), followed by toxin-producing bacteria (45; 8%), campylobacter (34; 6%), and salmonella (27; 5%).

Preparedness Exercise

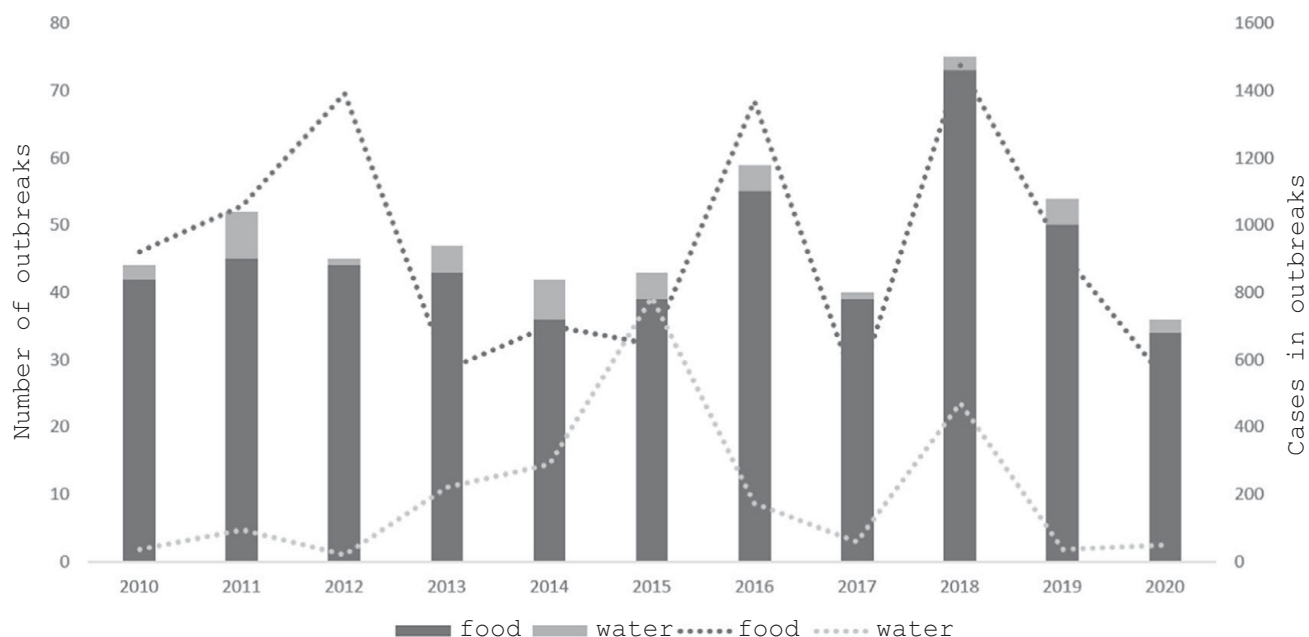
Of all EHUs in Finland, 42/62 (68%) participated in the exercise. The EHUs represented all Regional State Administrative Agencies

Table 1. Daily information feeds to participating environmental health units (EHUs)

Day	Information feed
Day 1	The Health Care Centre (HCC) reported that 4 people, 3 of whom were children with severe diarrhea, had been admitted to the emergency department during Day 1 and the day before. According to the HCC, symptoms appeared the day before in the evening in 2 people, and on Day 1 in the morning in the other 2. The patients were from 2 families in the same residential area.
Day 2	The HCC reported a total of 14 cases with symptoms similar to those on Day 1. Symptoms included vomiting and nausea, severe or bloody diarrhea, fatigue, and headache. Two children were hospitalized. Patient interviews revealed that most of the patients were from the same residential area. Common factors were: - Some of the children attended the same school or kindergarten. - The families had participated in a village association's Easter party 4 days before Day 1. - The residential area had its own water supply, which had quality problems during the spring floods.
Day 3	The HCC reported 11 new cases of gastroenteritis with symptoms similar to those on Days 1 and 2. Four cases were hospitalized. Those with symptoms lived on the other side of the municipal area, in different suburbs. In addition, the following information was provided: - There were some cases of stomach illness in the municipal school. - The kindergarten had substitute staff from another kindergarten due to a gastrointestinal illness. - The Easter party menu included grilled sausages and a salad with pasta and cheese. The factory-produced sausages consisted of several different brands, and the salad was prepared on a local farm. - The water supply used ozonation. No information was available on the maintenance of the water supply equipment because the permanent caretaker was travelling.
Day 4	The HCC reported 10 new cases of stomach illness in the morning. The symptoms were the same as in previously reported cases. Most of the water samples were negative, with only variable amounts of heterotrophs. However, 2 samples showed inconclusive results for coliforms. Inspections of the school and kindergarten kitchens revealed nothing significant, but no food samples were taken from the kindergarten. The farm had held a product presentation, offering tastings of their own products at a local market on the day before Day 1. In the afternoon of Day 4, the HCC reported that enterohaemorrhagic <i>Escherichia coli</i> (EHEC) had been found in 5 of the patients tested. A visit to the market revealed that a new experimental cottage cheese product made from the farm's milk had been included in the product presentation.
Day 5	An inspection of the central kitchen did not reveal anything significant and food samples were submitted to the laboratory. Water samples had confirmed the absence of coliforms. No new cases were reported.
Day 6	No pathogens were found in the food samples examined in the local laboratory. Samples from the milk filter collected from the farm were submitted to the Finnish Food Authority for examination. Cottage cheese samples were found preliminarily EHEC-positive by PCR. The EHEC finding was confirmed in the coming week. No new cases were reported.

Table 2. Description of preparedness scores for municipal environmental health units

Scored measures	Scoring	Influence of timeliness of measures on scoring			
		Day 1	Day 2	Day 3	Day 4
Municipal investigation group	0–8				
Existence of group (Yes/No)	0 or 2	NA ^a	NA	NA	NA
Group assemblies regularly (Yes/No)	0 or 2	NA	NA	NA	NA
Group assembled during exercise	0–2	2	1	0	0
Outbreak suspicion was notified	0–2	2	1	0	0
Outbreak communication	0–6				
Speed of communication	0–3	3	2	1	0
Use of several communication channels ^b	0–3	NA	NA	NA	NA
Restrictive measures	0–5				
Speed	0–2	2	2	1	0
Target of measures ^c	0–3	NA	NA	NA	NA
Sampling	0–6				
Patient	0–2	2	1	0	0
Food product	0–2	2	2	1	0
Drinking water	0–2	2	1	0	0
Suspicion of causative agent	0–2	2	1	0	0
Suspicion of source	0–2	2	2	2	1
Total	0–29				

^aNot applicable^bNo communication=0, 1 communication channel=1, 2 channels=2, 3 or more channels=3^cRestrictive measures concerning the source of outbreak=3, only boiling notice=2, other=1, none=0**Figure 1.** Number of food- and waterborne outbreaks and number of cases in outbreaks (dotted line) in Finland, 2010–2020.

in Finland, with the highest participation in Southwest Finland (100% of EHUs in the region) and the lowest in Northern Finland (25%) (Table 3).

The EHUs' median preparedness score was 15 (range 9–23) out of 29, whereas the median regional preparedness score ranged from 13–19 (Table 3) and did not differ significantly between the regions

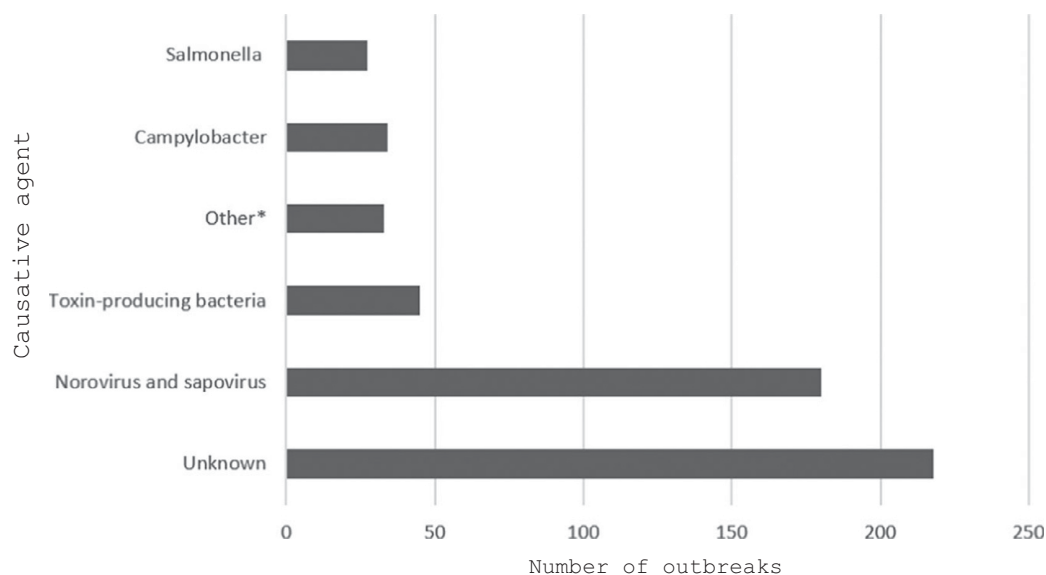


Figure 2. Causative agents in food- and waterborne outbreaks in Finland, 2010-2020.

*Other agents include parasites; chemical agents; bacteria other than salmonella, campylobacter, and toxin-producing bacteria; and viruses other than norovirus and sapovirus.

Table 3. Characterization and preparedness of participating municipal environmental health units (EHUs) regionally

Regional State Administrative Agency (region)	Number of EHUs in exercise (% of EHUs in the region)	Median number of food establishments (range)	Median number of person-years in food control in EHUs (range)	Median population of EHUs (range)	Resource I*	Resource II**	Median preparedness scores of EHUs (range)
Southern Finland	16 (88.9)	1790 (556–7035)	7 (2–29)	141 982 (25 376–648 042)	274	18451	15 (12–20)
Southwestern Finland	9 (100)	921 (493–3857)	6 (2–8)	52 224 (23 988–191 448)	302	17742	14 (10–19)
Western and Inland	9 (64.3)	1900 (341–2654)	6 (1–7)	50 936 (21 748–173 261)	402	15802	15 (9–23)
Eastern Finland	4 (50.0)	1625 (708–4914)	6 (2–9)	92 651 (38 345–161 925)	394	20536	18 (13–18)
Lapland	2 (40.0)	946 (778–1114)	5 (3–7)	67 519 (57 014–78 023)	270	19077	13 (11–15)
Northern Finland	2 (25.0)	1706 (1139–2273)	6 (2–10)	142 083 (33 508–250 657)	404	21570	19 (18–20)
Total	42 (67.7)	1417	5	64052	311	64052	15

*Median number of food establishments/person-years in food control in EHU.

**Median number of population/person-years in food control in EHU.

(Kruskal-Wallis test, $P = 0.25$). However, the preparedness score differed markedly within regions, such as the Western and Inland regions (9-23). The regional median preparedness score did not associate with the regional incidence of outbreak reporting ($P = 0.739$).

Of the participating EHUs, 55% (23/42) were responsible for the control of 1000-2500 food establishments, and 50% (21/42) had 200-400 food establishments/food control person-years. The preparedness score did not correlate with the EHUs' resources ($r = -0.07$, $P = 0.52$ for number of food establishments/person-years; $r = 0.05$, $P = 0.61$ for EHUs' population/person-years).

All EHUs had a previously established investigation team and 34 (80.9%) reported meeting regularly to maintain preparedness. In the exercise, 1 EHU investigation team (4.8%) assembled and reported the outbreak to the regional and national authorities on the first day of the outbreak, whereas the majority did so on the second day (Table 4). One-third (30.9%) of the EHUs communicated the outbreak to the public on the second day of the exercise, while over half (66.7%) did not issue a boil water notice at all during the exercise. The majority (83%) of the EHUs used 3 or more communication channels, while 12% used only 1 channel. The most

used communication channel was the municipal website (37/42; 88%). The prohibition and recall of a suspected food vehicle were carried out by 34 (80.9%) EHUs.

During the first day, patient sampling was organized by 28 (66.7%) EHUs, and water sampling by 1 EHU (4.8%). Water samples were taken by all EHUs by the third day, and food samples by the fourth day of the exercise. Most EHUs identified the correct vehicle on the third day of the exercise and the causative agent on the fourth day or later, with the time of suspicion ranging from the second to the fourth day.

Twenty-eight (66.7%) of the participating EHUs responded to the post-exercise survey. The exercise was considered necessary (mean 4.4 on a scale from 1-5), showed strengths (mean 4.0), and gave ideas for development (mean 3.7) in the EHUs operations.

Limitations

Preparedness exercises have limitations as they cannot completely simulate real-life situations. Time pressure, the consequences of actions, and the content of the information feed or exercise tasks may be experienced differently in a real-time situation than in an

Table 4. Activities of outbreak investigation teams (N=42) in municipal environmental health units (EHUs)

Activity	Proportion of EHUs (%)				
	Day 1	Day 2	Day 3	Day 4 or later	No activity
Team assembled	4.8	69.0	16.7	9.5	-
Outbreak suspicion notified to central authority	4.8	88.1	7.1	-	-
Team communicated to public	0	30.9	28.6	38.1	2.4
Team used restrictive measures					
Prohibition of food	0	0	2.4	80.9	16.7
Recall	0	0	0	80.9	19.0
Boil water notice	0	7.1	14.3	11.9	66.7
Patient samples taken	66.7	31.0	2.4	-	-
Water samples taken	4.8	69.0	26.2	-	-
Food samples taken	0	28.6	64.3	7.1	-
Suspicion about the correct causative agent	0	33.3	4.8	61.9	-
Suspicion about the correct vehicle	0	2.4	71.4	14.3	11.9

exercise. In our exercise, the scenario, the feeds and the description of the tasks were designed in a multi-professional team to come up with as authentic an exercise scenario as possible with unambiguous inputs. Still, some variation in the results may have been caused by participants interpreting the exercise task and feeds differently. However, there were substantial differences in preparedness, indicating that real differences exist between EHUs in this respect.

Discussion

Food- and waterborne illnesses and outbreaks are major public health problems. The mean incidence of reported outbreaks in our study (0.88/100 000) was in line with that reported in the EU in 2021 (0.89/100 000).⁹ Due to the COVID-19 pandemic in 2020–2021, the incidence of outbreaks in the EU decreased compared with the pre-pandemic years (mean 1.09/100 000 in 2017–2019). The main causative agents were the same across the EU. In Finland, norovirus and sapovirus caused 1/3 of food- and waterborne outbreaks. These viruses are also among the most significant outbreak causes in the EU because they accounted for the largest outbreaks counted by cases per outbreak.⁹ *Salmonella* was the causative agent in most foodborne outbreaks, and *Campylobacter* among the 4 most common outbreak causative agents in the EU, while in Finland, they caused 1/10 of the reported outbreaks. In Finland, toxin-producing bacteria were less common than in the EU, where they accounted for less than a third of the reported outbreaks.

In the future, climate change is assumed to alter weather events and cause prolonged droughts, temperature rise, and heavy rains.¹⁰ As a result, a doubling of *Campylobacter* cases by the year 2080 is predicted in Nordic countries.¹¹ An increase in cryptosporidium and giardia infections and their virulence is also expected due to rising temperatures and humidity.¹⁰ These pathogens are examples of common causes of food and waterborne outbreaks, suggesting that an increase in outbreaks as well as a growing public health concern are likely to be seen in the future.

Food safety is maintained through cooperation between public health, environmental health, and food businesses.¹² In outbreak investigations, a coordinated and punctual response is required from these partners. In most EHU areas in Finland, outbreaks do not occur regularly and maintaining investigation skills is

important to prevent food and waterborne illnesses and deaths. Multidisciplinary collaboration and preparedness are essential to resolve outbreaks promptly, prevent outbreaks from spreading, identify the factors leading to food contamination, and to implement control measures to prevent contamination in the future. Preparedness to investigate food- and waterborne outbreaks can be rehearsed through exercises.¹³ Preparedness exercises help to build and maintain adequate competence in municipalities with sporadic outbreaks, highlight the benefits of cooperation, identify gaps in strategies, and suggest actions required to better address outbreaks.

The incidence of reported outbreaks in regions did not associate with the regional median preparedness scores in the exercise. The highest scores were obtained in Northern Finland, where the incidence of reported outbreaks was lowest, while the lowest scores were in Lapland, with the second lowest incidence of outbreaks. In this exercise, overall preparedness did not vary significantly between regions, but there were marked differences between individual EHUs, indicating inconsistency in outbreak investigations between different local areas in Finland. Preparedness to investigate foodborne outbreaks is a result of many factors, such as workforce resources,¹⁴ outbreak response activity,¹⁵ and knowledge of foodborne pathogens and their epidemiology.⁷ Timely steps taken during the progress of the outbreak are vital for successful identification of the causative agent and vehicle. Because the differences in preparedness were not linked to the human resources in the EHUs, other factors, such as the comprehensiveness of the preparedness plans, ways to execute the plans, and knowledge of and attitudes towards the seriousness of foodborne illnesses, may have influenced local preparedness. These aspects should be emphasized in future EHU training.

Based on this exercise, outbreak communication was the most noticeable aspect of preparedness that could be improved. Differences in the speed of communication and the number of channels used, as well as in issuing a precautionary boiling notice, were observed between the EHUs. Timely communication with the public is one of the most important means of controlling an outbreak,¹⁶ but deciding when to release information may not be easy due to uncertainty about the possible causative agent, as well as fear of causing unnecessary distress among the public or negative consequences for food businesses.¹⁷ In addition to the challenge

posed by the timing of releasing information, reaching all the exposed people can be very difficult. Therefore, various communication channels, such as broadcasting services, social media, and handouts on-site, should be used, if necessary. As outbreaks are rare, EHUs do not always have comprehensive experience in communicating with the public and, hence, practicing communication with local press officers is important. The exercise suggests that national communication training in food- and waterborne outbreaks is needed.

In this exercise, the patient sampling was well organized, and it was initiated during the first day of the investigation in most of the EHUs. Patient samples provide valuable information on the causative agent and may guide the analysis of food and water samples, particularly when patients' symptoms are nonspecific.⁷ In the reported Finnish outbreaks, however, the causative agent was unknown in over 1/3 of cases. Similarly, foodborne outbreaks of unspecified etiology accounted for almost half of all outbreaks in the EU in 2021.⁹ The high number of unknown causes suggests that finding measures to enhance sampling would be needed in real life. In this exercise, water samples were taken during the first day in only 1 EHU. Because the patients in the exercise scenario were from the same residential area, a possible water outbreak could not be ruled out. Sometimes the causative agent may be found in water only at the beginning of the outbreak, prompting urgent sampling.¹⁸ As seen in the reported Finnish waterborne outbreaks in 2010–2020, contaminated water can lead to large and serious outbreaks and, hence, proactive water sampling is well justified.

Investigating outbreaks in real life is the most efficient way to assess preparedness and to update and revise investigation tools and procedures when needed. In addition, preparedness exercises are a good way to build readiness. Several types of exercises can be used to evaluate the preparedness and capabilities of outbreak investigations. Exercises based on case studies and simulations including time-constrained role playing have been developed,^{12,19} and interactive training based on playing cards suitable for both public health professionals and students has also been used.²⁰ A full-scale exercise resembles a real outbreak investigation as far as possible and utilizes the locations, tools, and staff that would manage the event in real life.²¹ A functional exercise is scenario-driven and enables the investigation team to verify their preparedness plans and functions by carrying out duties in a simulated outbreak investigation. In a tabletop exercise, a facilitator guides the exercise participants through a scenario with discussion of their roles and responses in an outbreak investigation.

This virtual functional preparedness exercise aimed to create as authentic a case as possible that would be resolved at the same time in all participating units. In the exercise, the participants, situated in their own localities, received situational information about the case by email. The intention was for the EHUs to take the same imaginary measures based on the situational information that would have been taken in a real outbreak situation. Measures included, for example, reporting a suspected outbreak to the national authorities, convening the investigation team, conducting inspections, taking samples, and public communication. The exercise lasted 6 days and was followed by a survey and feedback session. Based on the responses from the participants, the exercise appeared useful and the EHUs felt that similar exercises would be needed in the future.

Conclusions

This nationwide preparedness exercise revealed variation in readiness for outbreak investigation in EHUs in Finland, suggesting inconsistency

in the investigations between different areas. The variability in preparedness scores was high in both the highest and lowest outbreak incidence regions. Because outbreaks do not occur regularly in most EHU areas, preparedness exercises are necessary to maintain investigation skills. The causative agent was unknown in over 1/3 of the food- and waterborne outbreaks, indicating that measures to enhance sampling would be needed. Because many local investigation teams lack experience in public communication, national training on communicating about food and waterborne outbreaks is needed.

Author contribution. All authors contributed to the design and implementation of the exercise. RRF and JL drafted the manuscript. All authors commented the draft and accepted the final version.

Competing interests. The authors declare none.

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