



## Reported behavior, knowledge and awareness toward the potential for norovirus transmission by food handlers in Dutch catering companies and institutional settings in relation to the prevalence of norovirus



Linda Verhoef<sup>a</sup>, Giovanna Jaramillo Gutierrez<sup>a,b</sup>, Marion Koopmans<sup>a,c</sup>, Ingeborg L.A. Boxman<sup>d,\*</sup>

<sup>a</sup> Laboratory for Infectious Diseases and Screening, National Institute for Public Health and the Environment, P.O. Box 1, 3720 BA Bilthoven, The Netherlands

<sup>b</sup> European Public Health Microbiology Training Programme (EUPHEM), European Centre for Disease Prevention and Control (ECDC), SE-171 83 Stockholm, Sweden

<sup>c</sup> Department of Virology, ErasmusMC, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

<sup>d</sup> Food and Consumer Product Safety Authority, P.O. Box 144, 6700 AC Wageningen, The Netherlands

### ARTICLE INFO

#### Article history:

Received 24 September 2012

Received in revised form

3 May 2013

Accepted 11 May 2013

#### Keywords:

Questionnaires

Foodborne

Environmental samples

Environmental swabs

Food safety knowledge

### ABSTRACT

Norovirus (NoV) in ready to eat food has recently been defined as one of the virus-food commodity combinations with greatest public health concern. The role of food handlers therein has well been recognized. The aim of this study was to identify gaps in food handlers' education and to investigate possible associations between reported behavior, knowledge and awareness of NoV, and environmental presence of NoV. For this, face-to-face interviews were conducted using structured questionnaires in 1023 catering companies (i.e. restaurants mainly), 101 non-hospital health care centers, 52 hospital central kitchens and in 102 hospital in-patient units. In addition, three surface swabs were taken at each setting. Multivariate logistic regression was performed on data restricted to NoV high season months only, in which NoV was present in 21/374 (6%) catering companies and 37/233 (16%) institutional settings ( $p < 0.01$ ). The two independent determinants of presence of NoV on environmental surfaces identified were being situated in an institutional setting and having an attitude to continue food handling while sick with vomiting complaints. Several gaps in education and training were identified, demonstrating that knowledge on NoV was low, although awareness of NoV was significantly higher among food handlers in institutional settings than in catering companies. This is the first time questionnaires and environmental testing have been combined in the same study to identify issues of improvement. Training on all important aspects of NoV according to the recently developed Codex Alimentarius guidelines to control viruses in food is strongly recommended.

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### 1. Introduction

Noroviruses (NoV) are among the most common causes of viral gastroenteritis (GE) worldwide. In the Netherlands, the incidence of NoV illness in 2009 was estimated to be 3800 cases per 100,000 inhabitants, with an estimated burden over 1600 disability-adjusted life years (Verhoef et al., 2012). The virus is highly infectious (Teunis et al., 2008) and often seen in outbreaks with high attack rates in health care settings, cruise ships, catered events, a.o.

(EFSA, 2011; FAO/WHO, 2008; Meakins, Adak, Lopman, & O'Brien, 2003; Widdowson et al., 2004). Transmission of NoV occurs via the fecal–oral route directly from person-to-person but also indirectly via surfaces, water or food contaminated by fecal material or vomitus (EFSA, 2011; FAO/WHO, 2008). Infected people can shed NoV as early as 12 h after exposure until three weeks later (Rockx et al., 2002), with consequential possible shedding of the virus before onset of symptoms or after symptoms have subsided. Moreover, asymptomatic infections of NoV is quite common, as measured to be 5% (de Wit et al., 2001) to 12% (Phillips, Tam, Rodrigues, & Lopman, 2010) in non-outbreak situations and up to 19% during an outbreak situation (Vinjé, Altena, & Koopmans, 1997).

NoV in ready to eat food has recently been defined as one of the virus-food commodity combinations with greatest public health

\* Corresponding author. Tel.: +31 88 2230447.

E-mail addresses: [Linda.verhoef@rivm.nl](mailto:Linda.verhoef@rivm.nl) (L. Verhoef), [giovfer@yahoo.com](mailto:giovfer@yahoo.com) (G. Jaramillo Gutierrez), [marion.koopmans@rivm.nl](mailto:marion.koopmans@rivm.nl) (M. Koopmans), [ingeborg.boxman@vwa.nl](mailto:ingeborg.boxman@vwa.nl) (I.L.A. Boxman).

concern (FAO/WHO, 2008). The role of food handlers in NoV transmission has been illustrated by numerous outbreak investigations (Koopmans, von Bonsdorff, Vinjé, de Medici, & Monroe, 2002). Long-term shedding of viruses by either asymptotically or symptomatically infected food handlers may easily lead to viral contamination of ready-to-eat products (Boxman, 2013). This is especially true when hand hygiene is insufficient. Hands of food handlers may become contaminated during the shedding of viruses in feces, but also for example during changing diapers, or cleaning toilet areas. The viruses can subsequently be transmitted to food products or surface that has contact with food (Bidawid, Malik, Adegbinrin, Sattar, & Farber, 2004). The education level of food handlers or the presence of certified kitchen managers has been associated with reduced incidence of outbreaks (Hedberg et al., 2006). However, specific educational background on viruses and food safety may be low and differ considerably between people working in catering companies or those working in health care institutions.

Only recently the Codex Alimentarius has finalized guidelines on the application of general principles of food hygiene to the control of viruses in food, giving guidance on how to prevent or minimize the presence of human enteric viruses in food, in particular NoV and hepatitis A virus (FAO/WHO, 2012). The best dissemination of these guidelines would be by incorporation into national guidelines, which may however take some time and requires targeted training.

Therefore, assessing the food handlers' reported behavior, knowledge and awareness of NoV could help identify areas for targeted prevention specifically designed for the different food handler groups. For this reason, the aim of this study was to evaluate reported behavior, knowledge and awareness concerning potential transmission of viral food-borne illness by food handlers to identify gaps in education and training. Face-to-face interviews were conducted using questionnaires among food handlers working in catering companies preparing food for the general population and those in institutional kitchens preparing food for more vulnerable persons. In addition, environmental samples were taken to establish a possible association between determinants of food handlers' reported behavior, knowledge and awareness of NoV and presence of NoV.

## 2. Materials and methods

### 2.1. Data collection

#### 2.1.1. Study period and selection of locations

Data for this study was collected between January 2008 and March 2011 in three phases. In the first phase, between January 2008 and March 2009, inspections were performed in a broad range of catering companies, mainly restaurants, by officers of the Dutch Food and Consumer Product Safety Authority (NVWA) in the Netherlands. Data from this year-round NoV prevalence study have been published (Boxman et al., 2011). In the second phase, January 2010–April 2010, and third phase, February 2011–March 2011, inspections were performed in non-hospital and hospital health care institutions, respectively, but also in an equal number of restaurants in their vicinity during the winter seasonal peak of viral gastrointestinal disease only (Table 1).

Non-hospital health care settings included homes for the elderly people (74%) and nursing homes (15%). Hospital settings included central kitchen departments (34%) and de-centralized kitchens (66%). Staff in central kitchen department prepares food which is subsequently distributed to in-patient units, whereas staff, mostly nurses, in decentralized kitchens in in-patient units regenerate food to adequate temperatures and serve drinks.

**Table 1**

Study phases, periods and number of locations included in study.

Study phase	Period	Catering companies <sup>a</sup>	Institutional settings <sup>b</sup>
Phase 1	January 2008–March 2009	900	26
Phase 2	January 2010–April 2010	71	75
Phase 3	February 2011–March 2011	52	154
<i>Total</i>		<i>1023</i>	<i>255</i>

<sup>a</sup> Catering companies: i.e. restaurants mainly, but e.g. some take-away companies and canteens were included in 2008–2009.

<sup>b</sup> Institutional settings: i.e. hospital departments in 2011 and non-hospital health care settings in 2008–2009 and 2010.

Food handlers both in catering companies as well as in institutional settings, kitchen supervisors or company owners present at the time of the visit were questioned during a face-to-face interview, using a structured questionnaire. In addition, environmental swabs were collected from each location to test for the presence of viral RNA.

#### 2.1.2. Questionnaire topics

The following 24 questions covering 5 topics were included in the questionnaire (see Table 2, column 1):

- a) Intention of employer and employee to continue working while ill
  - Question 1: Have you ever been sick or felt sick while working? Yes/No
  - Question 2: If yes, what were the symptoms? None or non-GE/GE/combination
  - Question 3: Would you continue to work while experiencing GE symptoms, like diarrhea? Yes/No
  - Question 4: Would you continue to work while experiencing GE symptoms, like vomiting? Yes/No
  - Question 5: What do you do after being notified of GE symptoms in one of your employers or colleagues? Let food handler work/Send food handler home
  - Question 6: What do you do after being notified of GE symptoms in your employees' or colleagues' family? Let food handler work/Send food handler home
- b) Knowledge of disease and infectivity and awareness of GE viruses
  - Question 7: How long do you think a person is still infectious after recovery of GE symptoms? 1–2 days/3–7 days/7–14 days
  - Question 8: Do you think that vomit is infectious material? Yes/No
  - Question 17: Have you ever heard of GE caused by infection with a virus? Yes/No
  - Question 18: Have you ever heard of NoV? Yes/No
- c) Facilities available and personal hygiene;
  - Question 9: Is there a separate bathroom for the staff and the clients in your company? Yes/No
  - Question 10: Does the personnel bathroom have hand washing facilities? Yes/No/No, but close to bathroom (Close)
  - Question 11: What is used to dry hands after using the bathroom? Blower/re-usable cloth towel/single use paper towel
  - Question 12: Is hand washing instruction given to new workers? Yes/No
  - Question 25: Who uses the personnel bathroom that was sampled? Kitchen personnel/health care worker/kitchen personnel and health care worker/everyone including patients
- d) Cleaning and disinfection;
  - Question 13: Which cleaning products do you use for the kitchen (surfaces, door knobs)? Normal cleaning product

**Table 2**  
Frequencies of outcomes in study questionnaire.

Cat <sup>d</sup>	Question	Catering companies <sup>a</sup>		Institutions <sup>b</sup>		All N = 1278 n (%)	p-value <sup>e</sup>
		N = 1023 n (%)		Hospital	Non-hospital		
				N = 154 n (%)	N = 101 n (%)		
a	Q1 Have you ever been sick or felt sick while working?						
	Yes	550 (54)*	87 (56)	46 (46)	683 (53)	0.55	
	No	473 (46)	67 (44)	55 (54)	595 (47)	Ref	
a	Q2 If yes, what were the symptoms?						
	None or non-GE	837 (82)	133 (86)	94 (93)	1064 (83)	Ref	
	GE	19 (2)*	2 (1)	1 (1)	22 (2)	0.38	
	Combination	167 (16)	19 (12)	6 (6)	192 (15)	<b>&lt;0.01</b>	
a	Q3 Would you continue to work while experiencing GE symptoms, like diarrhea?						
	Yes	204 (20)	18 (12)	9 (9)	231 (18)	<b>&lt;0.01</b>	
	No	756 (74)	132 (86)	91 (90)	979 (77)	Ref	
a	Q4 Would you continue to work while experiencing GE symptoms, like vomiting?						
	Yes	99 (10)	10 (6)	4 (4)	113 (9)	<b>0.02</b>	
	No	861 (84)	143 (93)	96 (95)	1100 (86)	Ref	
a	Q5 What do you do after being notified of GE symptoms in one of employees or colleagues?						
	Let food handler work	86 (8)	17 (11)	11 (11)	114 (9)	0.26	
	Send food handler home	807 (79)	117 (76)	82 (81)	1006 (79)	Ref	
a	Q6 What do you do after notification of GE symptoms in your employees' or colleagues' family?						
	Let food handler work	637 (62)*	98 (64)	62 (61)	797 (62)	0.74	
	Send food handler home	165 (16)	19 (12)	18 (18)	202 (16)	Ref	
b	Q7 How long do you think a person is still infectious after recovery of GE symptoms?						
	1–2 days	187 (18)	47 (31)	25 (25)	259 (20)	Ref	
	3–7 days	419 (41)	66 (43)	54 (53)	539 (42)	0.08	
	7–14 days	78 (8)	11 (7)	10 (10)	99 (8)	0.16	
b	Q8 Do you think that vomit is infectious material?						
	Yes	712 (70)	122 (79)	74 (73)	908 (71)	0.13	
	No	114 (11)	23 (15)	20 (20)	157 (12)	Ref	
c <sup>e</sup>	Q9 Is there a separate bathroom for the staff and the clients in your company?						
	Yes	463 (45)*	145 (94)	88 (87)†	696 (54)	<b>&lt;0.01</b>	
	No	560 (55)	9 (6)	13 (13)	582 (46)	Ref	
c <sup>e</sup>	Q10 Does the personnel bathroom have hand washing facilities?						
	Yes	891 (87)	150 (97)	100 (99)	1141 (89)	Ref	
	No	47 (5)	1 (1)	0 (0)	48 (7)	<b>0.01</b>	
	Close to bathroom	85 (8)	3 (2)	1(1)	89 (7)	<b>&lt;0.01</b>	
c <sup>e</sup>	Q11 What is used to dry hands after using the bathroom?						
	Blower	100 (10)	0 (0)	3 (3)	103 (8)	Ref	
	Re-usable cloth towel	242 (24)	0 (0)	3 (3)	245 (19)	0.29	
	Single use paper towel	594 (58)	152 (99)	93 (92)	839 (66)	<b>&lt;0.01</b>	
c <sup>e</sup>	Q12 Is hand washing instruction given to new workers?						
	Yes	503 (49)*	128 (83)	87 (86)	718 (56)	<b>&lt;0.01</b>	
	No	520 (51)	26 (17)	14 (14)	560 (44)	Ref	
d <sup>e</sup>	Q13 Which cleaning products do you use for the kitchen (surfaces, door knobs)?						
	Normal (cleansing)	417 (41)	0 (0)	42 (42)	459 (36)	Ref	
	Disinfectants (e.g. QAC)	55 (5)	0 (0)	9 (9)	64 (5)	0.21	
	Chlorine	58 (6)	0 (0)	6 (6)	64 (5)	0.95	
d <sup>e</sup>	Q14 Which cleaning products do you use for the bathrooms?						
	Normal (cleansing)	167 (16)	0 (0)	25 (25)	192 (15)	Ref	
	Disinfectants (e.g. QAC)	38 (4)	0 (0)	10 (10)	48 (4)	0.17	
	Chlorine	305 (30)*	0 (0)	10 (10)	315 (25)	<b>&lt;0.01</b>	
d	Q15 Do you use different cleaning products after being notified of stomach flu in the company?						
	Yes	88 (9)	33 (21)	27 (27)	148 (12)	Ref	
	No	715 (70)	99 (64)‡	65 (64)	879 (69)	<b>&lt;0.01</b>	
d	Q16 If yes, which ones?						
	Normal (cleansing)	11 (1)	4 (3)	0 (0)	15 (1)	Ref	
	Disinfectants (e.g. QAC)	33 (3)	5 (3)	8 (8)	46 (4)	0.90	
	Chlorine	39 (4)	15 (10)	2 (2)	56 (4)	0.78	
b	Q17 Have you ever heard of GE caused by infection with a virus?						
	Yes	600 (59)*	141 (92)	88 (87)	829 (65)	<b>&lt;0.01</b>	
	No	423 (41)	13 (8)	13 (13)	449 (35)	Ref	
b	Q18 Have you ever heard of NoV?						
	Yes	209 (20)*	141 (92)	72 (71)‡	422 (33)	<b>&lt;0.01</b>	
	No	814 (80)	13 (8)	29 (29)	856 (67)	Ref	
e	Q19 These questions are answered by (owner/employee)						
	Employee	392 (38)*	133 (86)	86 (85)	611 (48)	Ref	
	Owner	600 (59)	2 (1)	3 (3)	605 (47)	<b>&lt;0.01</b>	
e	Q21 How many people work in your company?						
	1–10	690 (67)	57 (37)	45 (45)	792 (62)	Ref	
	11–25	242 (24)	40 (26)‡	40 (40)	322 (25)	<b>&lt;0.01</b>	
	26–40	61 (6)	21 (14)‡	10 (10)	92 (7)	<b>&lt;0.01</b>	
	>40	30 (3)	36 (23)‡	6 (6)‡	72 (6)	<b>&lt;0.01</b>	

Table 2 (continued)

Cat <sup>d</sup>	Question	Catering companies <sup>a</sup> N = 1023 n (%)	Institutions <sup>b</sup>		All N = 1278 n (%)	p-value <sup>c</sup>
			Hospital N = 154 n (%)	Non-hospital N = 101 n (%)		
e	Q22 For how many people the food is prepared in this kitchen?)					
	1–25	25 (2)	72 (47)	3 (3)	100 (8)	Ref
	26–50	30 (3)	33 (21)	6 (6)†	69 (5)	<b>0.02</b>
	51–100	38 (4)	7 (5)	23 (23)†	68 (5)	<b>&lt;0.01</b>
	>100	30 (3)	42 (27)‡	43 (43)	115 (9)	0.91
e	Q23 Is the hot meal prepared on site from raw materials?					
	Yes	9 (1)	22 (14)‡	35 (35)	66 (5)	0.95
	No	0 (0)	97 (63)	24 (24)†	121 (9)	Ref
	Partly	0 (0)	13 (8)	14 (14)	27 (2)	1.00
e	Q24 Are dirty dishes processed in clean food handling area by food handlers? (2011 only)					
	No	10 (1)	74 (48)	0 (0)	84 (7)	Ref
	Yes	22 (2)	51 (33)‡	0 (0)	73 (6)	<b>&lt;0.01</b>
	Partly	21 (2)	29 (19)	0 (0)	50 (4)	<b>&lt;0.01</b>
c	Q25 Who uses the personnel bathroom that was sampled?					
	Kitchen personnel (KP)	5 (0)	44 (29)‡	0 (0)	49 (4)	Ref
	Health care worker (HC)	0 (0)	37 (2)‡	0 (0)	37 (3)	0.98
	Everyone incl. patients	0 (0)	7 (5)	0 (0)	7 (1)	0.99
	KP and HC worker	0 (0)	61 (40)	0 (0)	61 (5)	0.98

<sup>a</sup> Catering companies: i.e. restaurants mainly, but e.g. some take-away companies and canteens were included in 2008–2009.

<sup>b</sup> Institutional settings: i.e. hospital departments in 2011 and non-hospital health care settings in 2008–2009 and 2010.

<sup>c</sup> p-values presented were calculated for catering companies (mainly restaurants) vs. institutions,  $\chi^2$ . Where frequencies were <5 the Fishers' exact test was used (i.e. Q2, Q4, Q10, Q11, Q13, Q14, Q16, Q23, Q25). p-values <0.05 were considered significant. Significant differences between catering companies and institutions are presented in bold. Sub-analysis comparing large (>10) and small ( $\leq$ 10) catering companies showed significant difference for Q1, Q2, Q6, Q9, Q12, Q14, Q17, Q18 and Q19, which are indicated with an asterisks (\*). Sub-analysis comparing hospital central kitchens to hospital de-centralized kitchens showed significant difference for Q15, Q21, Q22, Q23, Q24 and Q25 which are indicated with (‡). Sub-analysis comparing hospital to non-hospital institutions showed significant difference for Q9, Q18, Q21, Q22, and Q23, which are indicated with (†).

<sup>d</sup> Categories used: a) Intention of employer and employee to keep working while ill; b) Knowledge on disease and infectivity; c) Facilities available and personal hygiene; d) Cleaning and disinfection and e) Other aspects of the setting.

<sup>e</sup> Questions that were checked by inspectors.

(cleansing)/disinfectants (e.g. quaternary-ammonium based formulations (QACs)/chlorine

Question 14: Which cleaning products do you use for the bathroom? Normal cleaning product/disinfectants (e.g. quaternary-ammonium based formulations (QACs)/chlorine

Question 15: Do you use different cleaning products after being notified of stomach flu in the company? Yes/No

Question 16: If yes, which ones? Normal cleaning product/disinfectants (e.g. quaternary-ammonium based formulations (QACs)/chlorine

Question 24: Are dirty dishes processed in clean food handling area by food handlers? No/Yes/Partially

#### e) Other aspects of the setting.

Question 19: These questions are answered by Employee/Owner

Question 21: How many people work in your company? 1–10/11–25/26–40/>40

Question 22: For how many people the food is prepared in this kitchen? 1–25/26–50/51–100/>100

Question 23: Is the hot meal prepared on site from raw materials? Yes/No/Partly

#### 2.1.3. Environmental sampling

In addition to the questionnaires, at each setting two mixed surface swab samples were taken from surfaces in food preparation areas and one mixed surface swab sample was taken from the bathroom for NoV analyses. In brief, the first swab was used to collect a mixed surface sample from the grip of a refrigerator, the grip of the knife or serving spoon, and the handle of a cutting or mixing machine. Due to the absence of mixing or cutting machines in hospital in-patients units, surfaces from the microwave or the cutlery drawer were used instead. The second swab was used to collect a mixed surface sample from the soap dispenser, from the pepper-and-salt set or from a food storage box in the refrigerator. In

hospital in-patients units the handle of the dish washer was given as an alternative surface. The third swab was used to collect a surface sample from the flushing chain or knob and the toilet seat (both upper and undersurfaces) in the men's (employees') bathroom only, which was chosen for reasons of systematic sampling.

Analyses of samples from 2008 to 2009 for the presence of NoV RNA have been described (Boxman et al., 2011). Samples collected in 2010 and 2011 were analyzed with minor modifications in suppliers of reagents (Boxman, in preparation).

#### 2.2. Data analysis

##### 2.2.1. Categorization of data

Each location was categorized as either i) a catering company in which food is being prepared for the general population (i.e. restaurants mainly, but also included e.g. take away and canteens in 2008–2009) or ii) an institutional kitchen in which food is being prepared for a vulnerable population (i.e. hospitals and non-hospital health care centers, the latter including homes for the elderly people and nursing homes). Catering companies were further categorized into small ( $\leq$ 10 employees) or large ( $\geq$ 11 employees) companies, and hospital kitchens were categorized into central kitchens and decentralized kitchens in in-patient units (see 2.1.1).

##### 2.2.2. Frequency comparisons of questionnaire data

Frequencies of questionnaire outcomes were compared between the different location types, whereas statistical differences between catering companies (i.e. restaurant mainly) and institutional kitchens were analyzed by calculating p-values using  $\chi^2$ . Where frequencies were <5 the Fishers' exact test was used. p-values <0.05 were considered significant. In sub-analysis, answers as provided by owners of restaurants were compared to those provided by employees of the restaurants.

### 2.3. Logistic regression analysis to identify determinants of NoV presence

Univariate and multivariate logistic regression analysis were performed to identify possible determinants of presence of NoV in food preparation areas.

**Inclusion data:** To enable the identification of behavioral determinants of NoV presence, this part of the analysis was restricted to data collected in the NoV high seasonal months February and March (Kroneman et al., 2008), which were present for all study years (2008–2011). In sub-analyses complete determinant analysis for the complete group of questionnaires were performed as well, to test for potential dilution of determinants in the absence of NoV. Furthermore, NoV presence in catering companies in February and March of all study years 2008–2011 were compared to investigate whether the yearly difference in NoV activity (Lopman et al., 2004; Verhoef et al., 2008) had an effect on the prevalence on NoV in food preparation areas.

**Model building:** Analyses were performed for all locations together, as well as stratified for setting, i.e. for catering companies and institutions separately. The determinants of all questions were analyzed (see 2.1.1). In addition, study phase was included as a determinant phase I (2008–2009) vs. phase II and III (2010–2011).

**Criteria:** Missing values were categorized as a separate category in order to include the maximum number of records when building a multivariate logistic regression model. These none-informative categories are not presented in the tables. Variables were included in multivariate analysis when the  $p$ -value was  $<0.20$  for at least one of its informative categories (i.e. excluding the category 'missing' or 'not applicable') in univariate analysis. The variables remained in the multivariate model if the  $p$ -value was  $<0.10$  while using the backward selection procedure. To ensure a valid model, further reduction was performed until the number of degrees of freedom was  $\leq 10\%$  of the number of positive companies. All statistical analysis was performed using the statistical software SAS 9.2 (SAS Institute Inc., Cary, NC, USA) and the statistical software package R 2.14.0 (<http://cran.r-project.org>).

## 3. Results

A total of 926, 146 and 206 locations were visited in 2008–2009, 2010 and 2011, respectively (Table 1). Inspections were conducted in 1023 catering companies, mainly being restaurants, of which 333 (33%) had a company size  $\geq 11$  employees. In addition, inspections were done in 101 non-hospital institutions, mainly being homes for the elderly people (74%) and nursing homes (15%), and in 154 hospital departments, of which 52 (34%) were performed in central kitchens and 102 (66%) were performed in decentralized kitchens in-patient units.

### 3.1. Questionnaire outcomes

Comparisons of frequencies in the different settings are presented in Table 2.

#### 3.1.1. Intention of employer and employee to continue working while ill

Approximately 50% of all food handlers in the three investigated settings responded to have ever worked while feeling ill (Table 2), but a few had worked with gastroenteritis complaints (1–2%) or some more had worked with a combination of symptoms (6–16%). Nevertheless, 20% of the food handlers working in catering companies and 9–12% working in institutional setting reported to have the intention to continue work when experiencing diarrhea in the future, and 10% and 4–6% would do so when experiencing vomiting

complaints. Eight to 11% of the food handlers would not be sent home after reporting GE symptoms, whereas 61–64% of the food handlers would not be sent home after reporting GE symptoms in their family/household members.

#### 3.1.2. Knowledge on disease and infectivity and awareness of GE viruses

Eighteen to 31% of the respondents answered that a person is only infectious for 1–2 days after recovery, and 11–20% responded that vomit is non-infectious material. In catering companies the majority of the personnel (59%) was aware of a virus as a possible cause for GE symptoms, which was significantly lower than the 90% in institutions ( $p < 0.01$ ). Only 20% of personnel in catering companies had ever heard of NoV, compared to 84% of personnel from institutional kitchens ( $p < 0.01$ ). Sub-analysis showed that personnel from larger catering companies ( $\geq 11$  employees) were more aware of viral GE (71%) or NoV (27%) than personnel from smaller catering companies ( $\leq 10$  employees) (53% and 17% respectively, both  $p < 0.01$ , data not shown in table). In the context of health care settings, food handlers in hospital kitchens were significantly more often aware about NoV (92%) than food handlers in kitchens from non-hospital health care centers (72%,  $p < 0.01$ , data not shown in table).

#### 3.1.3. Facilities available for personal hygiene of food handlers

Hand washing instructions were provided significantly more often to food handlers in institutional kitchens (84%) than to food handlers in catering companies (49%,  $p < 0.01$ ), where personnel of big catering companies significantly more often received hand washing instructions (61%) than those in small catering companies (43%,  $p < 0.01$ , data not shown in table). Moreover, personnel from catering companies less frequently had access to a separate personnel bathroom (45%) or a hand washing facility in the bathroom (87%) than personnel from health care institutions (91% and 98% respectively, both  $p < 0.01$ ). Institutional kitchens more often used single-use paper towel to dry hands (96%,  $p < 0.01$ ) compared to catering companies (58%). In catering companies also re-usable, cloth towels (24%), blowers (10%) and other methods (9%) were used.

#### 3.1.4. Cleaning and disinfection procedures

Chlorine, which has been acknowledged as an effective disinfectant for NoV (FAO/WHO, 2008), was significantly more frequently used for cleaning toilets in catering companies (i.e. mainly restaurants) (30%) than in non-hospital health care centers (10%,  $p < 0.01$ ). In both settings, chlorine was not used more frequently after notification of cases of GE in the premises. Only 12% of food handlers in all settings indicated that they would change cleaning or disinfection procedures and products after being notified of GE, but this percentage was significantly higher in institutional settings (24%) than in catering companies (9%).

#### 3.1.5. Other aspects of the setting

Within hospitals, food more often was prepared on site from raw materials in central kitchens, and dirty dishes were more likely to be cleaned separately from the clean food handling areas and by other personnel in central kitchens as compared to kitchens in in-patient units (data for these sub-categories are not shown in table).

Catering companies, (i.e. restaurants mainly) had less personnel than institutional kitchens, and thus the owner was significantly more often the main respondent compared to institutional kitchens (60% vs. 2%,  $<0.01$ , data not shown). Sub-analysis of 601 owners and 394 employees of catering companies (mainly restaurants) showed the following significant differences between owners and employees. Owners were more likely than employees to work in small

companies (80% vs. 48%), and to keep working while experiencing vomiting (12% vs. 6%) or diarrhea (23% vs. 16%). They were less likely to have access to a separate toilet for personnel (42% vs. 50%) and more likely to clean this toilet with chlorine (32% vs. 26%) and to use a re-usable cloth towel (28% vs. 17%) after use. In addition, owners were less likely than employees to give hand-wash instruction to new workers (44% vs. 57%).

### 3.2. Detection of NoV on environmental swabs

Environmental swabs from surfaces, in kitchens as well as personnel bathrooms, were taken from 860/1023 (84%) catering companies and 249/255 (97%) institutional settings. NoV was present in 35 (4%) of the catering companies and in 37 (15%) of the institutional settings. When restricting to samples taken during February and March 2008–2011, 607 locations were included. NoV was present in 21/374 (6%) catering companies and 37/233 (16%) institutional settings ( $p < 0.01$ ). No significant difference in yearly NoV activity was observed between 2008 and 2012, based on swabs taken in February and March, with 13/143 (9%) NoV positive swabs in 2008, 9/127 (7%) in 2009, 14/132 (11%) in 2010 and 22/205 (11%) in 2011.

### 3.3. Determinants of NoV presence in different settings

The questionnaires answered by food handler working in the 607 locations sampled in February and March were included in this part of the analysis.

#### 3.3.1. Determinants of NoV presence in all settings

In univariate logistic regression analysis, the informative categories of 7 of the 26 variables were found to be associated ( $p < 0.20$ ) with presence of NoV, of which 6 variables were positively associated with NoV presence (Table 3A): institutional setting, intention to continue working after vomit complaints, letting food handler with reported GE stay at work, presence of a separate personnel bathroom, being aware of NoV, and being an employee. The preparation of meals on site from raw materials was negatively associated with NoV presence. All 7 associations with  $p$ -values  $< 0.20$  were used to build a multivariate logistic regression model. In this analysis institutional setting (hospital settings: OR 3.1, 95% CI 1.6–5.9; non-hospital health care centers: OR 4.5, 95% CI 2.2–9.4) and the intention to continue working after vomiting (OR 2.8, 95% CI 1.2–6.2) remained as independent positive determinants of NoV presence.

#### 3.3.2. Determinants of NoV presence in catering companies

When limiting univariate logistic regression analysis to catering companies (i.e. restaurants mainly), the informative categories of two variables were found to be significantly ( $< 0.05$ ) or borderline significantly negatively associated ( $p < 0.10$ ) with presence of NoV: being aware of viruses as a potential cause of GE, and a higher number of people working in the company (Table 3B). In multivariate logistic regression analysis, only awareness of GE viruses remained as a statistically significant negative association (OR 0.4; 95% CI 0.2–1.0) with NoV presence.

#### 3.3.3. Determinants of NoV presence in institutions

In univariate logistic regression analysis for institutional settings only, being hospital and non-hospital health care settings, the informative categories of 8 of the 26 variables were found to be associated ( $p < 0.20$ ) with presence of NoV. Of these, the following five factors were significantly associated ( $p < 0.05$ ) with NoV presence (Table 3C): ever having worked with illness complaints, intention to continue working after vomiting complaints, letting food handler with reported GE stay at work, awareness of NoV, and

**Table 3A**  
Determinants of NoV presence in all settings.<sup>a</sup>

Variable values	NoV	Univariate
	Pos/neg	OR (95%CI)
Setting		
Catering	21/353	Ref
Hospital	22/132	2.8 (1.5–5.3) <sup>b</sup>
Non-hospital	15/64	3.9 (1.9–8.0) <sup>b</sup>
Q4: Would you continue working if you have complaints of GE, like vomiting?		
No	47/483	Ref
Yes	9/45	2.1 (0.9–4.5) <sup>c</sup>
Q5: How do you proceed after being notified of GE in one of your workers?		
Let FH work	10/47	2.5 (1.2–5.3) <sup>b</sup>
Send FH home	38/440	Ref
Q9: Is there a separate bathroom for staff and clients?		
Yes	47/338	2.7 (1.4–5.3) <sup>b</sup>
No	11/211	Ref
Q18: Have you ever heard of NoV?		
Yes	32/250	1.5 (0.9–2.5) <sup>d</sup>
No	26/299	Ref
Q19: These questions are answered by		
Owner	14/195	Ref
Employee	39/320	1.7 (0.9–3.2) <sup>d</sup>
Q23: Is the hot meal prepared on site from raw materials? (only 2011)		
Yes	6/58	0.5 (0.2–1.2) <sup>d</sup>
No	22/96	Ref

<sup>a</sup> Settings: Catering companies are restaurants mainly, but e.g. some take-away companies and canteens were included in 2008–2009; Hospital settings are central kitchen departments and decentralized kitchens in in-patient units; Non-hospital settings are non-hospital health care settings, mainly being homes for the elderly people and nursing homes.

<sup>b</sup>  $p$  value  $< 0.05$ .

<sup>c</sup>  $0.05 < p$  value  $< 0.10$ .

<sup>d</sup>  $0.10 < p < 0.20$ .

the study phase in which samples were collected. Of these, only awareness of NoV was negatively associated with NoV presence. In the multivariate logistic regression analyses only the intention to continue working after vomit complaints remained as an independent significant association (OR 7.3, 95% CI 2.3–22.2).

Sub-analysis for all 3 models while including all questionnaires showed similar results resulting in the same conclusions. Some additional variables were included in the models as a result from more power of the analysis.

## 4. Discussion

To our knowledge, this is the first study that assessed reported behavior, knowledge and awareness, related to the foodborne NoV transmission and prevention thereof, among food handlers in catering companies (i.e. restaurants mainly) as well as in institutional settings. To our knowledge this is also the first paper where questionnaire outcomes are combined with measurements of the presence of NoV on site using environmental swabs using multivariate logistic regression to identify determinants. Outcomes of

**Table 3B**  
Determinants of NoV presence in catering companies, being mainly restaurants.<sup>a</sup>

Variable values	NoV	Univariate
	Pos/neg	OR (95%CI)
Q17: Have you ever heard of GE caused by infection with a virus?		
Yes	8/215	0.4 (0.2–1.0) <sup>b</sup>
No	13/138	Ref
Q21: How many people work in your company?		
$\leq 10$	17/214	Ref
$\geq 11$	4/139	0.4 (0.1–1.1) <sup>c</sup>

<sup>a</sup> Catering companies are restaurants mainly, but e.g. some take-away companies and canteens were included in 2008–2009.

<sup>b</sup>  $p$  value  $< 0.05$ .

<sup>c</sup>  $0.05 < p$  value  $< 0.10$ .

**Table 3C**  
Determinants of NoV presence in institutional settings.<sup>a</sup>

Variable values	NoV	Univariate
	Pos/neg	OR (95%CI)
Q2: If ever worked while being sick or feeling sick, what were main complaints?		
None or non-GE	30/179	Ref
GE	0/3	0.0 (0.0–>999) <sup>d</sup>
Combination	7/14	2.8 (1.1–7.4) <sup>b</sup>
Q4: Would you continue working if you have complaints of GE, like vomiting?		
No	30/188	Ref
Yes	7/6	7.3 (2.3–22.2) <sup>b</sup>
Q5: How do you proceed after being notified of GE in one of your workers?		
Let FH work	8/17	2.8 (1.1–7.3) <sup>b</sup>
Send FH home	26/157	Ref
Q7: How many days after recovery of GE do you think a person is still infectious?		
1–2 days	7/59	Ref
3–7 days	21/89	2.0 (0.8–5.0) <sup>c</sup>
7–14 days	3/16	1.6 (0.4–6.8) <sup>d</sup>
Q10: Is there a hand wash facility in the personnel bathroom?		
Yes	35/193	Ref
No	2/3	3.7 (0.6–22.8) <sup>c</sup>
Q18: Have you ever heard of NoV?		
Yes	28/175	0.4 (0.2–0.9) <sup>b</sup>
No	9/21	Ref
Q23: Is the hot meal prepared on site from raw materials? (only 2011)		
Yes	5/50	0.4 (0.2–1.2) <sup>c</sup>
No	22/96	Ref
Study phase		
2008–2009	4/6	Ref
2010–2011	33/190	0.3 (0.1–1.0) <sup>b</sup>

<sup>a</sup> Institutions are hospital central kitchen departments, hospital decentralized kitchens in in-patient units or non-hospital health care settings. The latter mainly being homes for the elderly people and nursing homes.

<sup>b</sup>  $p$  value < 0.05.

<sup>c</sup>  $0.10 < p < 0.20$ .

<sup>d</sup>  $p > 0.20$ .

the questionnaires identified several gaps in education and training, whereas multivariate logistic regression identified two independent determinants of presence of NoV in food preparation areas, i.e. being situated in an institutional setting and having an attitude to continue food handling while sick with vomiting complaints. Models for catering companies or institutional settings separately had different outcomes, and may therefore require slightly different interventional strategies per setting.

The most striking finding in this study was that knowledge on various aspects of contagiousness of NoV was low among food handlers in institutions as well as in catering companies despite the fact that awareness of NoV was significantly higher in the former group. Respondents of both groups gave incorrect answers on the duration of contagiousness after symptoms have subsided, the infectiousness of vomit particles, or indicated not to change cleaning into disinfection using chorine after GE events in the premises, or to not to stop food handling with GE complaints. As socially desirable results could have been given in the face-to-face interview with a food safety inspector the actual number of food handlers working with GE may be even higher. Other studies reported that 5 per cent of the respondents in the Environmental Health Specialists Network telephone survey among food service workers in restaurants indicated that they had worked while sick with vomiting or diarrhea (Green et al., 2005), whereas in another study, 12 per cent of the interviewed food workers said they had worked while suffering vomiting or diarrhea on two or more shifts in the previous year (Sumner et al., 2011).

The above identified lack of knowledge strongly argues for specific training on NoV for food handlers and their managers. This

requires well available and easy to understand education material given the part-time employment status of most restaurant employees, high employee turnover and the predominant mode of training being training on the job (Strohbehn, Sneed, Paez, & Meyer, 2008). Other prerequisites considered essential in limiting the presence of NoV in kitchens, e.g. providing hand wash instructions to new employees, having separate bathrooms for staff personnel, having hand wash facilities within the bathroom and using single-use wipes for hand drying (FAO/WHO, 2012) were in the present study better in place in institutional settings than in catering companies as in line with other studies on general food hygiene issues (FDA, 2009; Kassa, Silverman, & Baroudi, 2010; Strohbehn et al., 2008).

The two independent determinants of presence of NoV in food preparation areas identified by multivariate logistic regression were being situated in an institutional setting and having an attitude to continue food handling while sick with vomiting complaints. The latter determinant could only be identified as a unique outcome of the questionnaires used in the present study. When separate models were built for catering companies and institutions, this determinant was only seen in the model for institutional settings. This may be an interesting finding for improvement of effectiveness of prevention measures, which should not only be aimed at fecal contamination. It also raises the question if this attitude alone could explain the higher presence of NoV in institutional settings or that an explanation should be sought in e.g. communal areas between personnel and patients or personnel having dual tasks in food handling as well as care taking jobs. Further research is needed to investigate this hypothesis. In the model for catering companies (i.e. restaurants mainly) a negative association was found with awareness of NoV.

These results emphasize the need for tailored educational programs to improve food handlers' awareness with respect to NoV transmission. For institutional settings, interventions may be aimed at discontinuation of food handling after complaints of vomiting and for food handlers in catering companies being trained in the contagiousness of NoV in catering companies especially before start of NoV high season (November–April) (Kroneman et al., 2008). It would be a big step forward if food handlers and their (kitchen) managers would acknowledge the possibility of (asymptomatic) spreading of NoV (Okabayashi et al., 2008; Ozawa, Oka, Takeda, & Hansman, 2007), or e.g. other (bacteriological) pathogens, resulting in application of strict hand wash hygiene after using the bathroom or being in contact with fecal or vomit materials. Despite the different determinants in the separate settings, one could also argue for training on all important aspects of NoV according to the recommendations in the recently developed Codex Alimentarius guidelines to control viruses in food (FAO/WHO, 2012). Such programs should learn from experiences gained during evaluations of training programs on hand washing practices (Green et al., 2007; Pragle, Harding, & Mack, 2007), on general food safety issues (Egan et al., 2007; Kassa et al., 2010; York et al., 2009) or, in a broader perspective, on effectiveness of programs on surface cleaning in institutional settings (Goodman et al., 2008; Matlow, Wray, & Richardson, 2012) or reducing of infections rates (Schweon, Edmonds, Kirk, Rowland, & Acosta, 2013). Although training and intervention had the intended result in some of these studies, education alone did not always result in improved hand washing practices or improved food safety practices (Egan et al., 2007; Green et al., 2007; Pragle et al., 2007; York et al., 2009). Therefore, these authors argued in favor of multidimensional approaches to also address barriers such as time pressure, inadequate facilities and supplies, lack of accountability, lack of involvement of managers and co-workers, and organizations that are not supportive of changing practices. In addition, understanding and addressing

individual attitudes and beliefs may be helpful to inform strategies for sustained improvement of safe practices (Matlow et al., 2012).

## 5. Conclusion

In conclusion, our study contributed to the identification of the gaps in training in respect to NoV that need emphasis in future food safety training programs.

## Acknowledgments

The authors thank Geke Hägele, Kyara Klunder, Nathalie te Loeke and Claudia Jansen for analyses of swab samples, all officers of the Food and Consumer Product Safety Authority performing for performing interviews and collecting samples, Wilfrid van Pelt and Steen Ethelberg for helpful discussion and comments.

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