Journal of Management Inquiry
XX(X) 1–18

DOI: 10.1177/1056492613500718
jmi.sagepub.com
SAGE

Practising Uncertainty in the Face of Large-Scale Disease Outbreaks

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Abstract

In contrast to calculable risks, uncertainty—understood here as the unexpected and non-calculable—is under-researched despite its societal and organizational relevance and omnipresence. Against this backdrop, the present study investigates how organizations practise uncertainty in the face of the numerous large-scale outbreaks of disease in Germany between 2000 and 2012. I position this study in the body of knowledge on disasters and crises, normal accident theory, and high-reliability organizations, and propose a practising uncertainty perspective that focuses on how to deal with unexpected external events and/or their latent dangers. I identify two overarching forms of practice, namely, reducing (i.e., coping with unforeseen incidents) and inducing (i.e., championing an overarching cause) uncertainty. I show that actors use both these forms of practice, which constitute the basis of the framework introduced herein, intentionally or unintentionally depending on the differing and sometimes conflicting objectives of the organizations involved.

Keywords

crisis, uncertainty, practice, normal accident theory, high-reliability organization

Uncertainty is an omnipresent facet of modern life because surprises (Bechky & Okhuysen, 2011; Lampel & Shapira, 2001), crises (Scott, 1993), disasters (Shrivastava, 1987), and velocity in markets (Eisenhardt, 1989) are pervasive challenges that affect all areas of society. Following the distinction made by Knight (1921), in the present article I characterize uncertainty as situations in which actors face alternative scenarios that have inestimable probabilities of occurrence, compared with prior and statistical risks, the probabilities of which are calculable. Although a large and established body of research focuses on the understanding of risk, scholars have recently called into question some of the highly sophisticated probability models and mathematical representations used because of their idealized premises (see Munir, 2011, on the recent global financial crisis). In sharp contrast, relatively little scholarly attention has focused on the practices used to deal with uncertainty, which this article understands to be recurring social activities that are relatively stable in time–space (Giddens, 1984). This is hardly surprising, because studies of this type are challenging from a theoretical perspective; it would appear paradoxical to engage in recurring social activities while facing unexpected incidents with possibly detrimental effects. Such activities give rise to the notion of "practising uncertainty."

It is striking that despite the relevance and omnipresence in society of the phenomenon of practising uncertainty, very few approaches have aimed to conceptualize how organizations actually carry this out. One possible reason for this gap in the literature is that previous studies focusing on single incidents and the strategies considered to deal with them are predominantly reactive in nature, which tends to result in linear theoretical concepts (Lampel, Shamsie, & Shapira, 2009; Müller-Seitz & Schüßler, 2013). One reason for this tendency is the implicit notion that events (e.g., a tsunami or terrorist attack) are "focusing," which suggests that the resources for common objectives tend to concentrate on reducing the negative consequences of an unexpected event (Birkland, 1998; Scott, 1993; Turner, 1978). Moreover, previous studies have generally examined the reduction of risks and uncertainties with regard to the internal operations of an organization, usually with error-prone technologies in mind. Take, for instance, Perrow's (1984) normal accident theory (NAT), which highlights the role of complexity and tight coupling across critical components in an organization, or research on high-reliability organizations (HROs), which directs attention to the mindful management of internal operations (Weick & Roberts, 1993; Weick & Sutcliffe, 2007; Weick, Sutcliffe, & Obstfeld, 1999).

In light of the foregoing, I focus here on the manner in which organizations face unexpected events and how they

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practise uncertainty over time by applying a theory-building approach. Consequently, the present study addresses the following guiding explorative research question (Eisenhardt, 1989; Langley, 1999):

> **Research Question:** How do organizational actors practise uncertainty in the face of unexpected events in the face of large-scale outbreaks of disease?

I address this research question by analyzing an explorative case study of recent large-scale disease outbreaks in Germany. Specifically, I take the outbreak of enterohemorrhagic *Escherichia coli* (EHEC) and the more severe form of the infection, Hemolytic–Uremic Syndrome (HUS), which occurred in Germany in 2011, as reference points. I then reconstruct the ways in which actors practised uncertainty in previous outbreaks (i.e., before the EHEC outbreak), as well as during and after the EHEC outbreak. To allow partial generalization, I identify underlying patterns in actors' practices to generate a more robust theoretical account of how organizations practise uncertainty in the case of unexpected events that occur externally to them. This study also shows that crises are not merely events during which actors attempt to tackle a specific challenge coherently (cf. Cowen & Cowen, 2010; Müller-Seitz & Macpherson, in press; Ungson, 1998). In such conditions, distinct actors vie for the means to interpret the event in line with their overarching objectives—and even single actors may pursue conflicting objectives in parallel, accompanied by intended and unintended consequences in line with a practice perspective informed by structuration theory (Giddens, 1984).

I contribute to the literature on unexpected events in the following three directions. First, I refine previous research on HROs (Roberts, 1990a; Sagan, 1993; Weick & Sutcliffe, 2007) by elaborating on the notion of practising uncertainty from the perspectives of the actors involved, concentrating on the recurring social activities used in time–space to cope with (the latent danger of) unexpected events. Second, I introduce a framework that identifies two overarching forms of practice, namely, reducing (i.e., coping with unforeseen incidents) and inducing (i.e., championing an overarching cause and/or capitalizing on a specific incident) uncertainty. Not only do these two forms depend on the differing and often conflicting objectives of the organizations affected, they also vary across phases (i.e., before, during, and after an outbreak). In this regard, I refine previous research that has concentrated predominantly on attempts to reduce uncertainty (Birkland, 1998; Turner, 1978) and describe the conflict-prone relationship between these two types of practice. I also highlight the potential benefits of practising uncertainty, which are under-researched given the focus on alleviating the detrimental effects (Lampel et al., 2009). Third, in contrast to previous research on NAT (Perrow, 1984) and to the majority of HRO studies (Perin, 2006), I report insights from organizations that practise uncertainty over time in the face of unexpected events that emanate from external sources rather than from error-prone technologies. This approach is noteworthy because external sources of uncertainty are far more diverse and difficult to monitor than an organization's internal operations (cf. also Perrow, 2011).

The remainder of the article is organized as follows. First, I present my conception of practising uncertainty before positioning this study within the body of knowledge on how organizations face the unexpected. Second, I introduce the research setting—German actors involved in dealing with large-scale outbreaks of disease—in which the practice of uncertainty is omnipresent because of the constant danger involved in such a context. Third, I describe how I collected and analyzed the data. Fourth, I report on the way in which the sampled organizations practise uncertainty against the backdrop of outbreaks, particularly the EHEC outbreak. I conclude by tentatively suggesting that these findings might be applicable to other, related settings, and offer avenues for future research to address some of the limitations of the study.

Theoretical Background: A Practice Perspective on Facing Unexpected Events

A Perspective on Practising Uncertainty Informed by Structuration Theory

To analyze how organizational actors practise uncertainty in the case of large-scale outbreaks of disease, I refer to Giddens' (1984) conception of practices. A number of researchers have already successfully applied this theoretical lens to examine managerial practices in different settings (e.g., Jarzabkowski, 2008; Sydow & Windeler, 1998). In line with the approach of Giddens (1984), I perceive practices to be ordered, recurring social activities that are relatively stable in time–space and do not represent single isolated occurrences, but are rather part of an ongoing stream of activities in a particular context. The major advantage of a conception of practice grounded in structuration theory is that it enables the consideration of (re)produced activities. In particular, such a conception allows to focus on dynamics and contradictions (which are particularly relevant for the differing practices used by the investigated actors) rather than on stability and equilibrium.

For the purposes of the present study, I also refer to Knight (1921) to define uncertainty by focusing on those situations when organizational actors face alternative scenarios whose probabilities cannot be determined or be foreseen at all ("unknown unknowns"). This implies some form of enactment (Weick, 1969) and leads to the assumption that uncertainty is context-specific. In other words, organizations and their members perceive and assess uncertainty differently. Moreover, this conception of uncertainty contrasts sharply

with situations in which actors confront risk. To this end, Knight distinguishes between a priori risk (where the exact probability of an event is known) and *statistical* risk (where the probability of an event can be estimated based on the frequency of related events), because the latter comprises known alternatives (in Knight's terminology, "known unknowns"). The idea of distinguishing between uncertainty from a priori and statistical risks is also in line with Giddens' (1984) structurationist conception of agency. On one hand, he emphasizes the knowledgeability of agents who monitor reflexively the conditions of action (including the options at hand) and the consequences of this very action. On the other hand, he recognizes the importance of unacknowledged conditions of action, unintended consequences, unclear causal relationships between action and consequences, and the possible existence of vicious circles between unacknowledged conditions of action and unintended consequences from a dynamic perspective. Moreover, Giddens' (1991) conception of knowledgeable agents as those who strive for ontological security leaves room for their use of creative and imaginative skills to cope with uncertain situations such as large-scale outbreaks.

In connection with practising uncertainty, it is noteworthy that Giddens (1984, pp. 5-14, 1979, p. 56) presumes that the practices of agents who strive for ontological security (Giddens, 1991) are largely routine. Scholars consider such context-sensitive practices to be rooted in their practical rather than in their discursive consciousness. Only in the case of an unexpected event or the problematic intervention of a third party, as in the case of large-scale outbreaks, would actors be likely to question and consequently modify the routine character of their practices. These "critical situations" (Giddens, 1984, pp. 60-61, 1979, pp. 125–128) can then be brought into the discursive realm and can provide space for routines to be altered. Thus, with the help of the duality of structure (Giddens, 1984), which emphasizes the recursive interplay between action and structure, structuration theory not only enables us to analyze the dynamics of critical situations but also highlights the three interrelated dimensions of any action and structure, namely signification, legitimation, and domination. Actors refer to these structures in their social practices and use and (re)produce or transform them—and themselves—recursively. Taken altogether, a perspective in which practice is informed by structuration theory is sensitive to cognitive aspects, norms, communications, power asymmetries, and time–space aspects, all of which are relevant for taking into account the complex nature of dealing with large-scale disease outbreaks.

Unexpected Events as Sources of (Practising) Uncertainty

There is a long tradition in the social sciences of research on unexpected events. For the purposes of the present study, I focus on unexpected events that have detrimental effects for the organizations involved and for their environments even though positive outcomes might also ensue (see Lampel et al., 2009). To this end, three strands of literature are particularly important: the streams on disasters and crises, NAT, and HROs.

First, social scientific research has been sensitive to crises or disasters since Quarantelli (1954) introduced "disaster sociology," which relates to large-scale detrimental incidents. Although not necessarily relating to the term "disaster," this line of enquiry focuses on single events as well as on their retrospective analysis. It gained increasing prominence in the wake of a number of incidents from the late 1970s onwards, such as the accidents at the nuclear power plants at Three Mile Island (Moss & Sills, 1981) and Chernobyl, although obtaining contemporaneous information on the latter is somewhat difficult. Hence, ways to reduce the risks and uncertainty inherent in managing the operations of hazard-prone organizations and technologies remain of key interest (Reason, 1990). One widely reported unexpected event is the accident at a chemicals plant producing pesticides in Bhopal, where more than 3,000 people died and approximately 200,000 were injured (Shrivastava, 1987). Along similar lines, another well-documented case is that of the space shuttle Challenger that crashed shortly after take-off (Marcus & Nichols, 1999; Starbuck & Milliken, 1988; see also the discussion about the subsequent crash of the space shuttle Columbia; Starbuck & Farjoun, 2005). These studies have advanced our understanding of the technological and operational limits of dealing with allegedly safe technologies (Sagan, 1993). Furthermore, more recent organization sociological and managerial accounts of these incidents merit attention because they increasingly venture beyond purely technological accounts, sensitizing us to issues such as organizational culture that can substantially influence how an unexpected event unfolds (e.g., Snook, 2000; Vaughan, 1996). Similarly, anthropological studies of epidemics (e.g., Lindenbaum, 1979, 2001; Rosenberg, 1989, 1992) also stress the role of (though in this case not organizational) cultural issues and the contested nature of these incidents.

Second and closely related to the foregoing, Perrow's (1984) involvement in a special commission to examine the Three Mile Island incident inspired him to establish NAT, which suggests that technical failures in organizations that deal with complex and hazardous technologies are an inevitable consequence of the activities undertaken by these organizations. He rests his argument on two key intraorganizational sources that can systematically lead to errors: (a) complexity in the form of unintended sequences of interactions within and across different and complex technologies that tend to follow linear conceptions and (b) the tight coupling of the technological system, which results in time-dependent processes, invariant sequences of operations, a limited range of options to react to interruptions, and a lack of slack. His normative approach focuses on reducing the intraorganizational

risks and uncertainties inherent in hazard-prone technologies such as those found in nuclear power plants (Roberts, 1990a; Tamuz & Harrison, 2006). Moreover, NAT assumes that ensuring safe operations is only one objective among other political and economic objectives that influence the operations of an organization that deals with hazardous technologies (Hopkins, 1999).

Third, building on NAT, researchers interested in HROs have offered a more optimistic perspective for dealing with error-prone technologies (Sagan, 1993, p. 13). Therefore, the research contexts of HRO studies are often similar to those portrayed by Perrow (1984), including the aviation industry or nuclear power plants, which although displaying error-prone technologies at first sight, have extraordinarily low accident rates (La Porte, 1996; Roberts, 1990b). Key HRO themes include the way in which organizations train their employees to deal mindfully with technologies, track failures, or to be sensitive to the expertise of front-line employees (Starbuck & Farjoun, 2005; Weick & Roberts, 1993; Weick et al., 1999, for an overview, see Weick & Sutcliffe, 2007). This view contrasts with studies of organizational learning that explore, among other aspects, learning from failure (Baum & Dahlin, 2007; Haunschild & Rhee, 2004; Madsen & Desai, 2010; for a critical assessment, see Elliott & Smith, 2006; Müller-Seitz & Macpherson, in press), because given their reliability, HROs lack experience of failures from which they can learn (Weick & Sutcliffe, 2007; Weick et al., 1999), hence their preoccupation with failure. Consequently, such studies refine NAT in two important ways. First, they not only target engineering- and technology-related issues but also incorporate behavioral issues (Hopkins, 1999). Second, they target reactive measures in the aftermath of accidents and offer proactive managerial advice on how to prepare for potentially dangerous situations (Tamuz & Harrison, 2006; Weick & Sutcliffe, 2007; Weick et al., 1999). Despite these advances, however, some scholars have criticized insights from HRO research for lacking theoretical underpinning (Boin & Schulman, 2008).

In summary, by drawing on a practising uncertainty perspective while incorporating insights from the literature on disasters and crises, NAT and HRO theory should help shed light on the ways in which organizations face unexpected events. In the following sections, I discuss this perspective using a longitudinal case study of large-scale outbreaks of disease.

Research Setting: Organizations Involved in Dealing with Large-Scale Disease Outbreaks in Germany

The field of public health is suitable for an analysis of practising uncertainty from a management perspective because large-scale disease outbreaks are unforeseen events that usually have a severe societal impact and frequently require close and immediate interactions among affected organizations, including public authorities (e.g., Laursen, 2011). The present study thus examines the way in which actors practise uncertainty over the course of outbreaks such as SARS, BSE, the swine or avian flu epidemics, EHEC/HUS, and the norovirus in Germany, spanning a period from the mid-1980s until 2012. Data are put into perspective with regard to the EHEC/HUS outbreak in 2011. The relevance and timeliness of this outbreak is probably illustrated most vividly by the harm caused to consumers as well as the severe financial consequences for the retailers and other organizations involved (Handelsblatt, 2011). Moreover, high degrees of uncertainty typically characterize large-scale disease outbreaks because a large number of people are affected and ad hoc antidotes as well as the countermeasures that are suddenly needed (Robert Koch Institute [RKI], 2010).

Although large-scale disease outbreaks usually transgress national borders, I only explore the effects on the German public authorities involved, because I target my exploration on the way in which they practise uncertainty over time. This approach contrasts to related (and more linear) conceptions of single outbreaks (e.g., Lindenbaum, 1979; Rosenberg, 1992). Moreover, I use the 2011 EHEC outbreak in Germany as an anchor point to illustrate the findings because of the prominent effects of this outbreak on German residents. This focus is further motivated by the greater access to data (e.g., to interviewees and archival data from the respective authorities).

In Germany, there is a hierarchy that applies when national authorities deal with large-scale, food-borne disease outbreaks such as BSE, EHEC, or noroviruses. Two ministries, namely, the Federal Ministry of Health and the Federal Ministry of Food, Agriculture, and Consumer Protection, are involved, each supported by research institutions. For instance, the RKI that deals with human diseases supports the Ministry of Health, while the Ministry of Food, Agriculture, and Consumer Protection works with two research institutions. The Federal Office of Consumer Protection and Food Safety deals with food safety, while the Federal Institute for Risk Assessment deals with food- and animal-related risk assessments and communications. Furthermore, both ministries have counterparts at a federal state level and at a local level, where local health offices as well as local food safety and veterinary offices exist and carry out related tasks.

A theoretical sampling logic underpinned the present research context, because the objective was to investigate how organizations have practised uncertainty in the case of large-scale disease outbreaks in Germany since the 1990s, especially the EHEC outbreak in 2011 and its aftermath. Data availability made it possible not only to gather data retrospectively on how the actors practised uncertainty, as is common practice in related research (e.g., Cowen & Cowen, 2010), but also to obtain real-time data on the EHEC and

Table 1. Measures to Heighten Reliability and Validity.

	Research phase			
Criterion (Yin, 2009)	Design	Sampling	Data collection	Data analysis
Reliability	Case study protocol in particular for the outbreaks researched in real-time	Purposive sampling	Systematic usage of a case study database	Feedback from peers in the fields of management, organization sociology and veterinary as well as public health Pattern matching within and across cases
Construct validity	Refinements of constructs adapted from previous research on crises and a practice-oriented conception	—	Data triangulation by means of gathering archival, interview and participant observation data Researcher triangulation in the course of the research project	Three key respondents reviewed drafts Delineation of the chain of evidence
External validity	Theory-driven description of sampling criteria	Transparent description of the outbreaks, the actors and their interrelatedness as well as practices employed	—	—

norovirus outbreaks. The ability to follow new leads for theory building (Miles & Huberman, 1994) while establishing access to key persons in the respective fields to ensure timely and accurate data collection and analysis was also beneficial.

Methods: In-Depth Explorative Case Study

The study began in November 2010 as the initial phase of a new project in the field of food production. An initial workshop geared toward researching events discussed the nature of unexpected events with participants from the fields of strategic management, organization theory, and organizational sociology. In addition, experts from the fields of human and veterinary medicine, as well as a consultant specializing in public health sector clients participated in four roundtable discussions to comprehend large-scale disease outbreaks from an interdisciplinary standpoint. This approach enabled me to formulate research questions and pursue approaches by building on responses from respondents in the field. Furthermore, the participants in these roundtable discussions also served as a network of contacts to enable greater access to those public authorities affected by the outbreak, which I began to research in December 2010. Thus, it was coincidental that I had already begun to consider the issues associated with large-scale disease outbreaks when the EHEC/HUS outbreak suddenly began in Germany in May 2011. Consequently, I had the opportunity to conduct partial real-time data collection as the outbreak unfolded in the remainder of 2011. For this in-depth explorative case study research, I aimed to account for the qualitative research criteria recommended by Yin (2009). Table 1 provides an overview of the rigorous strategies used to conduct the research.

An interpretative research methodology was suitable to answer the main research question from a social scientific stance, because this can capture the way in which actors experience dealing with the unexpected (Yin, 2009). Furthermore, this approach is in line with my conception of practising uncertainty informed by Giddens (1984, 1990), who directs attention toward the subjective interpretations of the members of the field over time (cf. also Barley & Tolbert, 1997; Langley, 1999). Thus, I relate their comments to uncertainty if respondents consistently perceive a situation to be characterized by uncertainty as opposed to by risk. In addition, the selected in-depth case study approach enabled me to generate novel insights into how organizations practise uncertainty (Eisenhardt, 1989; Yin, 2009).

Data Collection

I collected retrospective and real-time data to track how actors practise uncertainty over time. Specifically, I used three data sources for triangulation purposes to heighten the validity of the findings, namely, field documents, interviews, and participant observations (Yin, 2009, pp. 114-118). First, as shown in Table 2, I drew on different field documents from a societal and media perspective. I complemented these

Table 2. Field Documents.

Type of document	Documents analyzed
Professional journals, trade magazines	Ärzte Zeitung online, Bundesgesundheitsblatt, Lancet, Medizinreport
International organizations	Eurobarometer, Eurosurveillance, WHO
Non-governmental organizations	Foodwatch, Greenpeace, National Consumer Council
Online media	bbc.co.uk, bloomberg.com, idw-online.de, ndr.de
Press releases by public authorities	Federal public authorities, Federal Institute for Risk Assessment, Federal Office of Consumer Protection and Food Safety, German government, European Parliament, European Council, final reports of the task forces and federal as well as state-level institutions
Robert Koch Institute	Epidemiological Bulletins (1997-2011), Infection epidemiological yearbooks (2001-2009), press releases
Daily press (print and online versions)	Die Zeit, Frankfurter Allgemeine Zeitung, Handelsblatt, Science

Table 3. Interview Data.

Type	Function	Number of interviews
Research institution	Veterinary public health (6), human medicine (4), prevention and investigation of food-borne disease outbreaks (2) and organizational behavior/strategy (3)	14
Hospital	Medical practitioners (7), head of "nephrology" unit (3)	10
Food producer	CEO (2), Director of regulatory affairs (1), manager of quality management (1)	4
Non-governmental organizations	Task force rapid response (2), farming and genetically modified food (1), globalization issues (1)	4
Public agencies	European organization (1), state agencies (4), local state agencies (6)	11
Other	Laboratory services (1), trade agency (1), consulting (2), media (2)	6
Sum		49

data sources by also gathering organizational data from key actors to better comprehend how the organizations portrayed the way in which they dealt with unexpected events.

In the next step, I collected archival data on the BSE, listeria, dioxin contaminations, norovirus, salmonella, SARS, and EHEC/HUS incidents in Germany from 2000 onwards. Data from the RKI and German parliament proved valuable because they offer access to various relevant documents for understanding how organizations and institutions face unexpected events. Parliamentary data proved mostly relevant for explaining the way in which federal ministries deal with uncertainty over time, while data from the RKI dealt with disease outbreaks in general over time, not just large-scale incidents such as BSE, SARS, and EHEC. In particular, I referred to the final reports of the RKI as well as other institutions that document in retrospect how the organizations responded. Furthermore, I gathered these data to trace how practices have changed over time. In this way, I identified other outbreaks as relevant to changes in the ways German public authorities faced large-scale disease outbreaks prior to the EHEC outbreak (e.g., salmonella, BSE, norovirus, and SARS). In particular, the norovirus outbreak in Germany of Autumn 2012, the largest outbreak ever reported in Germany that affected over 11,000 people (RKI, 2012), allowed me to track the changes that resulted from the EHEC outbreak in 2011.

This data-collection strategy served to avoid the distortion of results that might occur in relation to practising uncertainty due to heightened media attention and the publicity-oriented activities of those actors affected during the previous outbreak (Yin, 2009). Such an ex post reconstruction of organizational practices using primarily archival data provided an understanding of how actors reduced and induced uncertainty over time (Harding, Fox, & Mehta, 2002).

Then, I interviewed respondents from different organizations and with different functions affected by and involved in the disease outbreak (see Table 3). Researchers have used this approach for similar analyses in the field of management to account for the subjective experiences and assessments of the people involved and examine their connections with the respective organizations (Barley & Tolbert, 1997; Jarzabkowski, 2008; Perin, 2006; Snook, 2000).

Next, I collected data from seven conferences and workshops primarily attended by organizational representatives from the human medicine (five conferences) and veterinary medicine (two) sectors. Each event focused on EHEC exclusively or, in one case, a combination of EHEC, swine flu, and other epidemics. Collecting data at these events in the form of ad hoc interviews, gathering attendance lists, taking photographs, and taping speeches for internal analyses is in line with the assumptions of Giddens (1984, 1990) about the performance of structuration theory–informed field research for

strengthening the validity of a researcher's claims. Following the advice of Yin (2009), I took notes during each conference or workshop and for the subsequent 24 hr to understand the dynamics of how organizational representatives (re)interpreted the studied outbreaks. Such interpretations would be difficult to observe otherwise, and thus they served as an opportunity to grasp these "social microcosms" (Lampel & Meyer, 2008, p. 1030).

Finally, I conducted follow-up interviews, corresponded by email with key respondents, and paid a 1-day visit to a key hospital involved in the EHEC/HUS outbreak. At the hospital, I carried out three informal non-transcribed interviews with the vice president (approximately 30 min), the head of the nephrology department (90 min), and the head of nursing staff (40 min) to resolve remaining issues about the way in which uncertainty is practised by public health actors. In addition, three respondents (from one local and two national public authorities involved in the outbreak) reviewed a draft of the present article and provided comments. This process helped avoid misinterpretation of the data because it involved triangulation by multiple sources (Jarzabkowski, 2008) and thereby served to enhance the reliability of the data set (Yin, 2009).

Data Analysis

I conducted the data analysis in the following four stages. In stage one, all collected data were stored in a case study database that comprised three "sub-databases" for each phase of the outbreak as well as additional databases for the large-scale BSE, SARS, dioxin, and norovirus outbreaks to increase reliability (Yin, 2009; Table 1). Thereafter, I analyzed the interview transcripts and conference as well as workshop protocols and field notes to track the way in which actors practised uncertainty over time (i.e., across disease outbreaks). Such analysis along a temporal dimension as a first step is in line with previous process-based research that adopted a similar theoretical stance (Jarzabkowski, 2008; Langley, 1999).

Stage two consisted of describing how the different types of organizations practice and enact uncertainty (Weick, 1969). Members of the research team from the fields of management, organization sociology, and human and veterinary medicine then discussed these descriptions. This procedure was useful as an interdisciplinary, sensitizing meeting to discuss the way in which these different organizations practised uncertainty.

In Stage 3, I condensed the data in a joint analysis. One student, a research assistant involved in researching unexpected events since the beginning of the project, encoded the data and compared the analyses to maximize the reliability of the emergent framework of practising uncertainty. This student had practical experience in the field of public health and served as a continuous sounding board, identifying emergent topics or directing my attention toward the issues that needed addressing. Any remaining issues were resolved by contacting prior respondents.

In the next step, I coded the data at the level of a text unit, understood as words or sentences that form a coherent topic or idea. The initial coding resulted in 51 first-order categories provided as *in vivo* codes by informants or related only to the descriptions of incidents or phenomena I identified in the field without evaluating or interpreting them. In line with previous research (e.g., Jarzabkowski, 2008), I placed these text units into different categories (often more than one category) and systematized the data by generating mutually exclusive second-order themes that I then grouped hierarchically to identify upper, second-order themes and lower, first-order categories. I then collapsed the second-order themes into third-order themes. Whereas the first-order categories were purely descriptive, the second- and third-order themes represented researcher-interpreted constructs.

I first identified ways of *reducing* uncertainty and then focused on practices related to *inducing* uncertainty, after which I merged both themes into the overarching conception of practising uncertainty. Interestingly, some actors, for instance those in hospitals, engaged in reducing and inducing uncertainty. Consequently, I reconsidered my categorization and developed an alternative way of grouping the first-order categories and second-order themes. In effect, this approach identified different forms of practising uncertainty, for instance coping with uncertainty during an outbreak as a form of reducing uncertainty (e.g., through so-called recipe-based cohort studies by the RKI as a first-order category). Thereafter, I included the second-order themes under the two third-order themes of reducing and inducing uncertainty.

In the final stage, I derived and compared practices for the different types of organizations involved to highlight similarities and differences. This comparison strengthened the internal and external validity of the findings, because literal (or theoretical) replication was possible given that the studied organizations demonstrated similar patterns for the practise of uncertainty (Yin, 2009). This approach enabled me to develop underlying generalizable constructs and relationships concerning the practise of uncertainty at the organizational level (Yin, 2009, p. 38), namely, the constructs of reducing and inducing uncertainty as well as their accompanying subsets of practices.

Table 4 shows some examples from different sources, from which I identified and verified the themes of practising uncertainty over time. It is worth noting that I only integrated those perspectives shared by interviewees with different types of occupations and hierarchical levels to strengthen the internal validity of the claims made.

Results: Practising Uncertainty in the Face of Large-Scale Disease Outbreaks

Figure 1 provides an overview of the findings and the structure for the following sections. The presented empirical analysis of large-scale disease outbreaks centers on the 2011 EHEC outbreak in Germany. However, I contextualized this

Table 4. Illustrative Data Centred on the Phases Before, During, and After a Large-Scale Disease Outbreak.

Overarching practice (organizations primarily involved)	Characteristics	Phase	Data source	Illustrative evidence
Reducing uncertainty	Recurring social activities in time–space geared toward lowering potential or actual detrimental effects of unexpected situations.	Before an outbreak	Archival data	"Already on May 9, i.e., prior to the announcement of the EHEC epidemic, the BfR [Federal Institute of Risk Assessment] warned about the consumption of raw bean sprouts and wrote on its website in an almost prophetical fashion that 'vegetable food like [. . .] salad that is consumed in a raw form, represents an important albeit still underestimated source of contagion' for EHEC infections" (Elger et al., 2011; my translation)
			Interview data	"In the European Union we have a rapid warning system that demands that such [EHEC/HUS] disease outbreaks are reported immediately" (I-10; my translation)
		During an outbreak	Archival data	"In order to support the analysis of the EHEC outbreak in Germany, on Friday, June 3, 2011 [. . .] a task force was installed. The overriding objective of this 'EHEC' task force was [. . .] to identify the food-related source of the EHEC outbreak and stop the outbreak" (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, 2011; my translation)
			Interview data	"in these cases [situations like the EHEC/HUS outbreak] you call the person and say "well, it looks like this . . . and we have this or that problem, could you take some of our patients?", then they check their resources and say "yes" or "no" [. . .] This [exchanging EHEC/HUS affected as well as other patients between hospitals] is not something that had been planned in a structured manner beforehand" (I-19; my translation)
		After an outbreak	Archival data	"'The task force [. . .] proved its value and is supposed to become a permanent instrument of crisis management' [. . .] reported a ministerial spokesperson. During the upcoming ministerial conference on consumer protection [. . .] in mid September in Bremerhaven Aigner [the present Federal Minister of Food, Agriculture and Consumer Protection] will present her plans for the task force" (Ehrenstein, 2011; my translation)
			Interview data	"There are clear indications that there'll be legislative changes . . . there is some juridical change to be expected [in particular with regard to] shoots"(I-16; my translation)
Inducing uncertainty	Recurring social activities in time–space geared toward capitalizing on potential or actual detrimental effects of unexpected situations.	Before an outbreak	Archival data	"Over many years the German medical practitioners, public authorities and consumer protection lobbyists have ignored the killer germ. Also the German media missed this opportunity [this is surprising, given] that there are also some German scientists already researching EHEC, but their warnings remained unheard" (Weidmann, 1999, 153; my translation)
			Interview data	"If a product does not contain 5% protein, but only 3% protein, and that is beyond the legal threshold, then this will have an effect upon the quality of the product and, thus, the product will not be marketable, as this is not in line with the law. However, the product is not a threat to the consumer, it is just likely to be lowering the value of the product [and] then it is enough to inform the retailers and they will start to stop selling the product, but the public will not be informed" (I-9; my translation)
		During an outbreak	Archival data	"Also other experts pointed at structural deficits: the German public authorities appear to have 'no clue' concerning how to tackle epidemics was put forward by ARD [the leading German public television broadcasting station] journalist Klaus Weidmann [who] analyzed the German crisis management a decade ago. At this point in time the competences 'have been moved to the different federal states, a fatal flaw' according to Weidmann, who calls for rapid deployment teams consisting of microbiologists and hygiene experts in order to identify the source of the infection. If this does not happen, human lives are at risk" (Tagesschau, 2011; my translation)
			Interview data	"and then the company [Alexion, producer of the potentially relevant drug Soliris] said okay, it was a win for the company, an image win and in the end they had a tremendous amount of data that showed the suitability of the product - or not" (I-11; my translation)
		After an outbreak	Archival data	"We were quite lucky during the EHEC crisis as the outbreak unfolded in areas where we have good procurement" (Lauterbach in Ärzte Zeitung, 2011b)
			Interview data	"It is at times a little crass to talk about things like this, but that's a marketing opportunity [for drug companies], it got people's attention, you can't ignore it" (I-17)

Note. EHEC = enterohemorrhagic Escherichia coli; HUS = hemolytic–uremic syndrome.

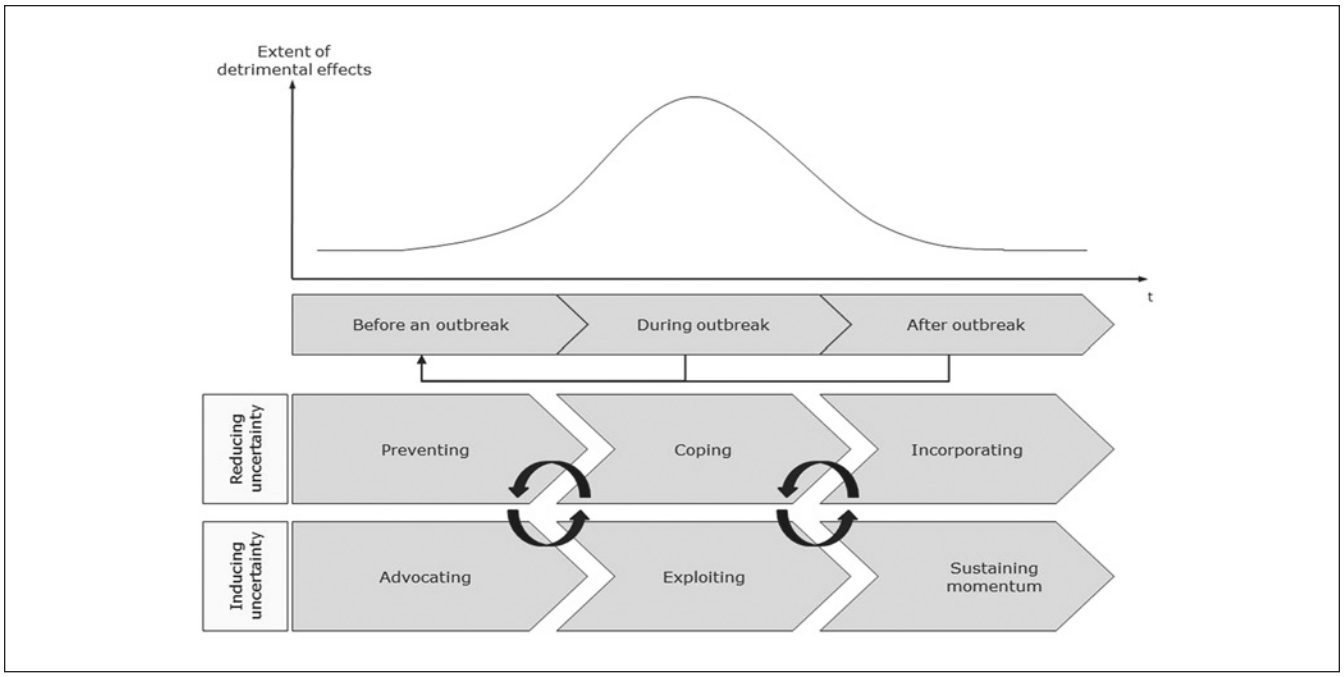

Figure 1. Practising uncertainty in the case of large-scale disease outbreaks.

particular outbreak in relation to those that occurred beforehand (e.g., BSE) and afterward (e.g., the large-scale norovirus outbreak in 2012) to capture how practices are (re) produced over time. To this end, I identified reducing and inducing uncertainty as the two overarching practices that actors used, each of which consisted of a subset of practices that varied over time (i.e., before, during, and after an outbreak). The practices used during and after an outbreak in turn (re)produced those pursued during the phase before the next outbreak (indicated by the reverse arrows).

Reducing Uncertainty

During the pre-outbreak phase, I found that organizational actors, including public federal authorities and research institutions, practise uncertainty by means of prevention, in that they attempt to take precautionary measures that might buffer potentially detrimental effects. Although the EHEC outbreak was unforeseeable, the studied actors seemed to prepare for such a "class of events" (I-3), as one respondent from a research institution termed it. Therefore, although the specific disease that causes an outbreak does not seem to be relevant per se, there is an overarching concept of how to deal with the latent danger of outbreaks related to a "class of events" (I-3). These precautionary measures ranged from mundane operative issues, such as the preparation of templates for press releases (triggered among others by the outbreak of Creutzfeldt–Jakob disease; I-23) or permanently issuing public health documentation, to organizational measures such as the provision of crisis units (I-29).

These practices were refined over time based on the outcomes of previous outbreaks. For instance, the number of large-scale disease outbreaks in the 1990s (e.g., HIV, SARS, BSE) resulted in the decision to split the former German Federal Health Office (the counterpart of the U.S. Food and Drug Administration) into two institutions, the Federal Institute for Risk Assessment and the Federal Office of Consumer Protection and Food Safety. In a similar vein, the authorities established nationwide databases to collect outbreak information and pandemic plans (Engels, 2011).

The findings also showed that actors might struggle to identify the state of an outbreak before its official recognition (Frank et al., 2011, p. 2). However, although it is the responsibility of public authorities to define a large-scale disease outbreak in Germany, respondents repeatedly aired the belief that the definition of an outbreak also relates to the interpretation of the case at hand. For instance, two locally contemporaneous incidents (e.g., cases of disease in two families) could represent an outbreak depending on the local authorities' specific interpretation of a "normal" situation. This is noteworthy because, in this phase of the outbreak, only those in charge of the response or those directly affected by the outbreak tend to acknowledge its existence and latent danger. Thus, in the case of the EHEC outbreak, during the days before the official announcement by public authorities, warnings were aired, but only within the scientific community. Indeed, these warnings went largely unheard by the public (I-06; I-11) even though the number of infections had already passed what most actors would consider to be a normal threshold:

> In Germany there have been several outbreaks [. . .] I have been researching this disease pattern for almost 30 years, but I haven't seen anything like this before. Usually, such severe progressions are extremely rare. The extent has shocked me. (Karch, 2011)

It is noteworthy that uncertainty also exists during an outbreak. Although the existence of an outbreak is no longer uncertain (because it is occurring), there are still numerous uncertainties in the way in which it will unfold, as well as in its origins. During the EHEC outbreak, for example, this uncertainty was—from the perspective of the public institutions and hospitals—primarily related to the epidemiological nature of the outbreak (I-17; I-47; I-48; Jansen & Kielstein, 2011). Analysis of the "Infection Epidemiology Yearbooks" showed that approximately 800 reported cases of EHEC occur per annum in Germany. However, in the short time span from May to June 2011, EHEC affected 4,321 individuals in Germany and caused 53 fatalities. This unexpectedly severe outbreak resulted in intense public and media-related attention, which single outbreaks of EHEC rarely attract. Moreover, the source of the contamination remained unclear for several weeks. The EHEC outbreak was further imbued with risk because the fatality rate was extraordinarily high, the people affected were atypical of EHEC outbreaks (young women as opposed to children or men), and the specific type of EHEC had never before been isolated. In addition, as the EHEC outbreak unfolded, it was unclear whether the contamination was the result of harvests contaminated by sandstorms or bioterrorism (I-05; Tschiersky-Schöneburg, 2011). This key factor remained confidential at first to avoid public concern, but the public authorities still assigned substantial resources to its investigation. They were also highly alert to bioterrorism following the anthrax-contaminated letters found in the United States (I-11), and they began carrying out biennial training sessions at the national level in 2002 (I-5; I-6; I-31). Only later did the fear of bioterrorist attacks appear in some newspaper reports (e.g., Zastrow in Ärzte Zeitung, 2011a).

Against this backdrop, I identified a primary method of practising uncertainty during a large-scale disease outbreak, namely, the practice of coping. Coping herein implies the immediate activities geared toward stopping the outbreak by decreasing the number of people who acquire new infections and helping improve matters in the organizations affected initially. For example, in the current case, the research institutions involved put substantial efforts into trying to discover the source of the outbreak to determine how to stop further contamination (Bielaszewska et al., 2011; I-06; I-13). In the course of this research, scientists coped with uncertainty as they constantly refined their methods and interpretations related to the detection of the source of the outbreak and prevention of further damage. Furthermore, leading medical practitioners and hospital managers refined their ways of communicating with each other by exchanging information regularly on online forums (I-19). Although this approach was relatively novel, it turned out to be an effective way of disseminating information (I-48).

Another activity that contributed to coping involved the better-established methods developed and refined during previous outbreaks. Actors were interested in collecting information continuously from patients to track down the source of the outbreak and in constantly refining their methods in line with emerging information. The introduction of a recipe-based cohort study best illustrates this approach, in which pictures of restaurant meals were shown to those affected. This novel method culminated in the identification of bamboo shoots served by a restaurant in the northern German city of Lübeck as one source of the outbreak (Federal Institute for Risk Assessment, 2011).

Although scientists sought publicity from the exercise, and thus intensified the search for the source of the outbreak (I-08; I-38), external pressure on the actors involved also strengthened the search. Supranational organizations such as the European Union demanded immediate action, and public authorities in Germany passed this pressure on domestic research institutions (Aigner, 2011). Government authorities at the federal and state levels were particularly keen to demonstrate their control over the situation (I-10), leading to frequent announcements concerning the current state of the outbreak and intermediate successes:

> that was building up a reputation as a crisis manager from my point of view, that is, they [the respective public authorities] tried to position themselves more favourably. (I-07)

In this vein, the authorities faced a dilemma common to most large-scale disease outbreaks (I-33). On one hand, they wanted to keep the public up-to-date by communicating progress. On the other hand, in the face of an incoherent picture during the outbreak, their forecasts and statements led involuntarily to further uncertainty (Rissland et al., 2013). For instance, the senator from the Office for Health and Consumerism in the federal state of Hamburg announced very early in the outbreak that cucumbers were deemed to be the source of contamination:

> We will remove them [cucumbers] from the food chain where necessary. We are asking consumers not to eat them. (Prüfer-Storcks, 2011)

After cucumbers turned out *not* to be the source of the infection, the senator received criticism for having issued this warning too early and having disobeyed the basic rules of risk communication—the function for which, not least for such occasions, the Federal Institute for Risk Assessment had been installed. For instance, the European Commissioner for Health and Consumer Policy, John Dalli, criticized the drawing of such premature conclusions:

> I would like to stress it is crucial that national authorities do not rush to give information on the source of infection which is not proven [. . .] as this spreads unjustified fears in the population all over Europe (Dowling, Walker, & Gabbatt, 2011)

Nevertheless, other German ministers and leading figures made similar statements because their overarching aims were to gain positive media coverage by announcing successes and to demonstrate how well the public authorities could deal with uncertain situations (I-11). Indeed, leading figures frequently defended this approach, notably the president of the RKI, Reinhard Burger:

> We wanted to avoid new infection sources. It's a difficult balance. You don't want to wait a long time and on the other hand you don't want to cry wolf. (BBC, 2011)

Once the number of cases of EHEC and HUS infections had returned to average levels, the public authorities declared that the outbreak was over. Perhaps the most relevant announcement in this respect again came from Reinhard Burger, who declared that the public authorities had detected no more cases related to the specific form of EHEC and therefore "that the largest EHEC outbreak in Germany is over" (RKI, 2011).

The practices used subsequently relate to the post-outbreak phase. In this phase, I identify incorporation as a key practice; this refers to the different actors involved reflecting on the (lack of understanding of the) recent outbreak and formulating safeguarding measures geared toward the next (Ärzte Zeitung, 2011a). One incident in which incorporation seemed to have occurred was the announcement by the federal government that it was converting the so-called EHEC taskforce into a permanent organization to support the public authorities, in particular the Federal Ministry of Health and the Federal Ministry of Food, Agriculture, and Consumer Protection (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, 2011; Ehrenstein, 2011; Federal Government, 2011). During the outbreak, the inception of the EHEC taskforce aimed to concentrate resources across federal and state authorities given the outcomes of previous outbreaks such as avian influenza and eggs contaminated with dioxin, when public actors collaborated less than in the case of the EHEC outbreak (I-20). The introduction of this new project also aimed to avoid any confusion about the different responsibilities of the various governmental institutions involved, which were often unclear from the perspectives of the public authorities, the media, and the public. This confusion had resulted in severe criticism from diverse institutions, including the World Health Organization and key EU representatives, as well as from medical practitioners and opposition parties in Germany (Sprehe, 2011; I-25). Although it remains unclear whether the taskforce was or is operating effectively, its creation can at least be identified as a result of the EHEC outbreak (i.e., a form of incorporation). Furthermore, in early 2012, the Federal Minister for Health revised the Infection Protection Act, thereby shortening the time lag before an EHEC incident becomes reportable, to detect future outbreaks faster by discerning outbreak patterns earlier (I-11).

Another example of incorporation was the first EHEC Symposium in September 2011 hosted by the German Nephrological Society. During this meeting, the key German actors involved in the outbreak exchanged information and made sense of how the event had been handled. Although the symposium praised the actions of certain actors (e.g., the microbiologist who detected the EHEC strain), it criticized others for the way in which they handled the outbreak. For instance, when the president of a leading public health institution claimed that the authorities had tackled the crisis quickly and effectively, nearby participants began to mumble in disagreement, telling me that he had "become a bureaucrat, blind to reality." Similar to the EHEC symposium, the RKI convened an interdisciplinary workshop geared toward sharing the lessons learned across public institutions (Schielke & Stark, 2012).

The public authorities had the opportunity to refine these practices in Autumn 2012 when Germany experienced its largest outbreak, that of the norovirus (RKI, 2012). Although there were no fatalities, the outbreak affected 11,000 people, particularly children, leading to public outcries and widespread media attention. However, the taskforce operated immediately and successfully to identify the outbreak as originating in strawberries imported from China, and to contain it by refining the methods used during the EHEC outbreak (I-33; I-37; I-38).

Inducing Uncertainty

Under inducing uncertainty, I found a set of three practices, namely, advocating, exploiting, and sustaining momentum, the implementation of which depends on the phase of the outbreak. Advocating involves the ongoing activities related to the promotion of an overarching concern where no concrete incident is present. These activities can take diverse forms, such as continuous campaigning for a particular cause (e.g., safer food; I-6) or directing attention to the economic damage a potential disease outbreak might cause (I-48). For instance, the nongovernmental organization Foodwatch supports consumers in this regard (Foodwatch, 2011).

Another more direct form of advocating is the practice of lobbying, by influencing political agendas. The public authorities pursued a number of food-borne disease scandals in Germany prior to the EHEC outbreak, including dioxin-contaminated eggs (I-47), or bioterrorist fears (RKI, 2010) when scientists highlighted the potential dangers. The nongovernmental organization "Greenpeace" links large-scale disease outbreaks to its overarching political agenda for

saving the environment. However, such measures frequently fail to be effective because they lack the necessary attention from the media or society in general (I-08).

In the phase during the outbreak, I discerned the practice of exploiting, namely, making use of a specific incident (e.g., an outbreak) as an opportunity to rally further support for the overarching cause pursued during advocating. This phase offers room for maneuvre because the incident in question represents a window of opportunity for rallying support and attention given the widespread managerial, media, political, and public awareness generated. In addition to the nongovernmental organizations referred to above, pharmaceutical companies seemed to relish the opportunity to draw attention to the tried-and-tested advantages of their products for treating affected patients. Most prominently, the company Alexion benefited from having its drug Soliris (a potential antidote to EHEC) tested on and administered to a large number of affected patients (I-24). This case is particularly noteworthy because the drug was unapproved for the treatment of EHEC/HUS when used by "desperate" medical practitioners in the state of Hamburg, who deemed it their "last chance" (I-19). While the public authorities eventually allowed its use because of the large scale of the outbreak and the related uncertainties and anxieties, it also had the positive side effect that Alexion shares subsequently tripled in value (Laursen, 2011).

Moreover, the research institutions involved (e.g., the RKI) also had an interest in pointing out the latent dangers that arose from the outbreak (I-10). The rationale behind exploiting is that heightened public awareness and media attention serve the actors' purposes (I-11; Ärzte Zeitung, 2011b), while associated organizations are often keen to make use of such an event to obtain further (often desperately needed) financial resources. For instance, these resources might take the form of compensation for the acute losses suffered by the hospitals involved in the treatment of people affected by EHEC or HUS. On their behalf, the vice president of Hanover Medical School, Andreas Tecklenburg, announced that the affected hospitals needed compensation as they were disproportionately affected (Spiegel online, 2011). This observation echoes those of a number of institutions that called for additional funding or for further resources and competencies (I-8; I-11; I-28). For instance, one newspaper article suggested that the RKI ought to be able to recruit ad hoc project teams based on the competencies required to tackle a given outbreak, similar to the recruitment of reservists in the army (Ärzte Zeitung, 2011c). By contrast, research institutes such as the Institute for Hygiene/National Consulting Laboratory for HUS of the University of Münster induced uncertainty by pointing out the present unknown latent dangers as well as the dangers lurking on the horizon. Future dangers might relate directly to EHEC or to an outbreak of another disease that might harm even more citizens and affect more organizations compared with EHEC (I-11; I-14).

During the crisis, EHEC/HUS-related medical journals deviated from their normal publishing schedules and gave predominance to studies of EHEC (I-11). In these papers, authors frequently drew attention to the lack of understanding of the situation and demanded further investigations. One of the mentioned reasons was that "we [as a medical scientific community] lack an explanation for the increased virulence" (Bielaszewska et al., 2011). Other public figures also offered further support for this cause. For example, Reinhard Burger induced uncertainty by stating the following:

> The number [of cases] will come down, but how long it will take I am not sure. It could be weeks, months. (BBC, 2011)

After the outbreak, inducing uncertainty was related to sustaining momentum, which I define as an attempt to maintain a sense of urgency with regard to one's own cause in relation to an unforeseen incident. For example, research institutes and nongovernmental organizations attempted to sustain momentum by issuing statements about the latent danger of and demanding additional resources to tackle future outbreaks (Jähn, 2011). To this end, we can interpret documenting results by publishing ex post reports or scientific journal articles as not only reducing uncertainty in terms of disseminating information, but also sustaining momentum by highlighting the difficulty in treating the outbreak and the potential dramatic consequences had the outbreak been more severe or lasted longer (I-48). Take, for instance, Helge Karch, Germany's leading expert in the field of EHEC, who pointed out that "it is of course our goal to avoid further outbreaks in the future" (Dreising, 2011). Another example is transnational European projects that investigate the nature of EHEC and other "new epidemic threats" (European Centre for Disease Prevention and Control [ECDC], 2011). In a similar vein, calls to alter existing practices and institutions were noticeable. The aforementioned institutionalization of the taskforce and shortening of EHEC notification time span—against the backdrop of inducing uncertainty—was a positive side effect of the outbreak, as these measures represented successful outcomes for the subsequent norovirus outbreak (I-33; Krause et al., 2013; Rissland et al., 2013).

Proponents often made use of the outbreak as a vehicle to emphasize their requests, such as the first EHEC Symposium, where key actors from the fields of public policy, research institutions, hospitals, and pharmaceutical lobbyists exchanged information. For instance, Reinhard Brunkhorst, chairperson of the German Society for Nephrology, suggested an orientation toward the United States, where the Center for Disease Control in Atlanta is the leading authority on tackling large-scale disease outbreaks (Beneker, 2011). Actors repeatedly aired these calls from various angles and with differing interests in mind. The following statement by the president of the Federal Institute for Risk Assessment is

representative of how inducing and reducing uncertainty are intertwined inextricably:

> Indeed, up until today it [the Federal Institute for Risk Assessment] is a successful concept [but] we need to be accustomed to crises-like phenomena […] that can and will occur again and again. (Hucklenbroich, 2011)

This caution seems to be justified given the observation that despite containing the outbreak and reducing and treating the number of people affected, the actual sources of outbreaks are usually never identified (I-6). This also applies to the EHEC outbreak, which reminds the actors involved vividly of the uncertainties and risks still surrounding their post-outbreak activities:

> The European Food Safety Authority […] published a technical report concluding that a specific cargo of fenugreek seeds imported from Egypt was the most likely common link. The exact point of contamination in the food chain was not established. (Sprenger, 2011, p. 6)

Discussion: Toward a Practising Uncertainty Perspective

Organizations affected by large-scale outbreaks of disease use varied practices to face uncertainty depending on the phase of the outbreak and the concerns of the organization in question. Given that large-scale disease outbreaks such as BSE, SARS, or EHEC are unexpected and novel, actors face and practise uncertainty during all their phases. However, organizations are ever aware of the latent danger of yet another outbreak and often gather substantial experience from previous outbreaks to refine the practices used. As with any explorative enquiry, future researchers must generalize the present findings with caution. Nonetheless, these findings are at least partially applicable to other settings in which practising uncertainty is commonplace, especially for other large-scale disease outbreaks or emergencies that involve public agencies.

By generalizing the findings from this empirical case, I contribute to the literature in three important ways. First, I propose a practising uncertainty perspective that contrasts with the vast majority of studies that concentrate on a priori or statistical risks (Knight, 1921). Instead of making linear assumptions about how to face (single) risks (e.g., Rosenberg, 1989, 1992), the practice-oriented interpretation of my findings across unexpected events suggests that actors face these events by applying different practices. Although not focusing on practices (but following a linear conception in line with Rosenberg, 1992) and adopting an anthropological perspective, Lindenbaum (2001) observes similar phenomena in her review of how epidemics have changed societal and political ways of dealing with large-scale disease outbreaks. To this end, I illustrate how practices are (re)produced over time (e.g., refining established methods to tackle outbreaks). This observation is in line with Giddens' (1984, 1990) conception that the subjective interpretations of groups of actors facing unexpected events are decisive. Hence, when respondents state that uncertainty existed and that the outbreak was unprecedented, I interpret such situations to be uncertain. Nonetheless, I also admit that some aspects could be interpreted as statistical risks in the "Knightian" (Knight, 1921) sense. For instance, narrowing the source of contamination by interviewing infected patients about the food they consumed and the restaurants they visited resembles the idea of statistical risks, or in managerial parlance, "risk [*sic*!] management."

Building on this observation, I further suggest that scholars ought to view the Knightian triad of uncertainty, statistical risks, and a priori risks, as a continuum rather than treating them as distinct categories. As a result, I also tentatively suggest that unexpected events such as large-scale disease outbreaks are likely to start with situations characterized by uncertainty (in the present case, it was evident that the strain was unknown and that actors were overwhelmed by the unprecedented HUS and mortality rates) before these events increasingly display the risks to be tackled. Furthermore, the actual practices used are manifest in the constant (re)production of the activities pursued in time–space. Hence, I venture beyond the individual level of analysis (e.g., as opposed to Reason, 1990), because practices are patterns of recurring activities. The closest conception in this regard might be the ideas put forward by Weick on sensemaking and enactment that inform HRO research (Müller-Seitz & Macpherson, in press; Müller-Seitz & Schüßler, 2013; Weick, 1995; Weick & Sutcliffe, 2007; Weick et al., 1999). However, my practice-oriented conception—including the three phases of before, during, and after a crisis—differs at least partially from previous studies on disasters, NAT, and HROs, because I go beyond focusing only on the pre-event phase (as predominantly considered by HRO studies) or the post-event phase (as predominantly examined by disaster and NAT studies; cf. also Müller-Seitz & Schüßler, 2013; Shrivastava, Sonpar, & Pazzaglia, 2009).

Second, whereas the majority of studies of disasters, NAT and HROs analyze how organizations reduce uncertainty or risks (Perrow, 1984; Reason, 1990; Tamuz & Harrison, 2006; Weick & Sutcliffe, 2007), I offer a more nuanced conception. In this sense, I provide no normative or prescriptive advice but rather suggest that the overarching interests of the actors involved as a result of the outbreak are decisive. The findings suggest, in line with previous studies, that organizations might indeed have an interest in reducing uncertainty (Berthod, Müller-Seitz, & Sydow, 2012; Birkland, 1998; Weick & Sutcliffe, 2007). Most prominently, perhaps, this is relevant to government authorities at different levels, primarily the national (e.g., the two federal ministries involved) and state levels (e.g., the northern German states where

the largest numbers of outbreaks occurred). Nonetheless, theoretically in line with a practising uncertainty perspective, it is also noteworthy that some activities geared toward *reducing* uncertainty might have the unintended consequences of actually *inducing* uncertainty (e.g., complicating handling the outbreak and reporting the situation transparently to the public), an issue to which previous research on dealing with crises has not been sensitive.

However, as I have illustrated here, some organizations might also be interested in inducing uncertainty to gain support for their objectives (e.g., hospitals), namely, by exploiting a specific incident in line with an overarching cause. I deem this to be an interesting finding, because this aspect has attracted only scarce attention in events-based research, perhaps because it is somewhat counterintuitive. Hence, I presume that unexpected events do not necessarily have a focusing character (Birkland, 1998) in terms of reducing uncertainty. Instead, I argue that they are rather prismatic in nature, because different actors practise uncertainty in an often conflicting fashion. Although inducing uncertainty is not conceptualized in the related literature, NAT might be most sensitive to my concern, because Perrow (1984) not only focuses on securing operations in an organization as the exclusive objective but also puts this objective into perspective, arguing that this represents only one among other objectives (e.g., economic ones). By venturing beyond the literature primarily addressed in this study (i.e., crises, HRO, and NAT), I find similar observations made by scholars interested in impression management (e.g., Bansal & Clelland, 2004) or organizational communication (e.g., Coombs, 2007). Although these studies are informative because they point out inducing uncertainty, they tend to fail to integrate the pre-crisis phase into their accounts (for an exception, see Elsbach, Sutton, & Principe, 1998).

Concerning the two overarching forms of practising uncertainty studied here, I also add to previous research on disaster, NAT and HROs by observing that some organizations use different forms of practising uncertainty simultaneously. For instance, in the present case, when research institutions were attempting to identify the source of the EHEC outbreak, they were coping with uncertainty (a form of reducing uncertainty). However, in some cases, they were also exploiting uncertainty (i.e., inducing uncertainty), such as when they pointed out the dramatic consequences during the outbreak and, in particular, the remaining potentially harmful uncertainties, which led to an easing of administrative duties (e.g., shortened notification times during the outbreak or gaining additional resources immediately). This finding sheds new light on (inducing) uncertainty. Viewed against the backdrop of my findings, (inducing) uncertainty is thus not only negatively connoted, but also has much in common with the observations of Lampel and colleagues (2009). I thereby suggest that rare and unusual events such as large-scale disease outbreaks also have a productive facet, in that they open up new possibilities for those actors that practise uncertainty.

This argument further points out a theoretical difference in the primarily signification-oriented—in Giddens' (1984) parlance—conception of sensemaking (Weick, 1995) as a perception informed by structuration theory, which is also sensitive to legitimation and domination being inherently intertwined with signification. For instance, this might include applying novel practices (e.g., shortening notification times to legitimize the demands of public health institutions) or (re)allocating resources (e.g., buying new medical equipment or rotating critical nursing staff). What is more, this observation, informed by a practice–theoretical lens, also helps explain why learning from failure might be inhibited (Elliott & Smith, 2006) because it highlights actors' differing interpretations (Müller-Seitz & Macpherson, in press). This observation contrasts with the body of knowledge on (predominantly technological) failures that favors a more optimistic perspective of the actual possibilities of learning from failure (e.g., Baum & Dahlin, 2007; Haunschild & Rhee, 2004; Madsen & Desai, 2010). In addition, these studies are rarely sensitive to phase and practice during a crisis because they are primarily concerned with the way in which organizational learning unfolds afterwards (Müller-Seitz & Schüßler, 2013). For example, although Giddens (2011) examines the context of climate change, parallels can also be drawn with his claim that threats of global warming should not dominate the discourse. Instead, he calls for scholars to pay attention to the opportunities that result from this phenomenon, such as initiating and entering new markets geared toward new and more environmentally friendly technologies.

Finally, the instances of uncertainty and risk identified in the present case bear two features that at least partially inform existing research. On one hand, the locus of uncertainty resides outside the organizations involved in practising uncertainty. This finding contrasts with those presented in NAT and most HRO studies, whose measures focus on internal operations (for an exception, see the introductory chapter in Weick & Sutcliffe, 2007). Moreover, in contrast to the HRO preoccupation with failure (Weick & Sutcliffe, 2007; Weick et al., 1999), disease-related incidents occur frequently. Put differently, the organizations I researched herein constantly face different forms and scales of disease outbreaks. This aspect contrasts with the error-prone but error-free (i.e., highly reliable) operations of HROs. On the other hand, despite the focus of previous disaster, NAT, and HRO research on hazardous technologies, I introduce into the debate non-technology-related threats that cause uncertainties and risks. This phenomenon-driven observation merits attention, because the forms of practising uncertainty I observed (e.g., campaigning) differ from those primarily discussed in disaster, NAT and HRO

studies (e.g., monitoring technological parameters in a nuclear power plant).

Concluding Remarks

The present study examines how actors practise uncertainty in the face of unexpected events in the case of large-scale outbreaks of disease. Informed by structuration theory, I introduce a practising uncertainty perspective and report how this applies before, during, and after outbreaks, as illustrated by epidemics before and after the 2011 EHEC outbreak in Germany as well as by the EHEC outbreak itself. Thus, I inform previous research in the following two main directions. First, I direct attention to how actors actually practise uncertainty including intended and unintended consequences, and call for longitudinal approaches to comprehend such phenomena. Second, I explore the two overarching practices of reducing and inducing uncertainty as well as the nature of uncertainty (in this case, residing outside organizations and being non-technical in nature).

Although I consider my findings to be generalizable to some extent, the contribution of this study is limited in the way typical of explorative research (Harding et al., 2002). First, I did not gather any ethnographic data during the outbreak, which might have explained how reducing and inducing uncertainty relate to one another (e.g., in the case of hospitals). However, I tried to mitigate this common shortcoming (Lampel et al., 2009) by triangulating data and conducting interviews as soon as possible after the outbreak. Moreover, the present insights derived from a public setting might be difficult to transfer to for-profit settings. Whereas inducing uncertainty is relevant in public settings, for-profit settings might be more susceptible to financial and other micro-political pressures (Perrow, 1984, 2011). Finally, restrictions concerning data access as well as ethical and juridical issues further limit the insights gained and information available for analysis. Although this restriction applies to crisis or disaster research in general (Harding et al., 2002), it held particularly true for this study given that lawsuits regarding the EHEC outbreak and norovirus cases are ongoing at the time of writing.

Given these limitations, I conclude that the present study offers fruitful ground for future research. For instance, although it offers explorative evidence of how actors practise uncertainty in the face of unexpected crises, more detailed data from key actors on reducing and inducing uncertainty would help provide a more comprehensive picture of the way in which organizations practise uncertainty. Exploring the productive effects of inducing uncertainty might also improve our comprehension of the rationales that actors pursue (cf. Michel, 2007 for the case of investment banking). Another potentially fruitful and more conceptual research avenue would be to elucidate which types of organizational constellations (e.g., ephemeral inter- and intraorganizational projects or more permanent inter-organizational networks; Berthod, Müller-Seitz, & Sydow, in press; Sydow, Müller-Seitz, & Provan, 2013) operate in which types of settings (Moynihan, 2008) as well as the practices that they use, which might differ substantially.

It might also be interesting to analyze distinct patterns across the different phases of a disease outbreak. For instance, the data analysis presented herein suggests patterns related to the practising of uncertainty by certain actors. In hospitals, for example, emphasis might be placed on preventing uncertainty before an outbreak, whereas during an outbreak, staff manage and exploit uncertainty in an ambidextrous fashion. I only touched on these issues in the present study, but they deserve further attention to elaborate on practising uncertainty as a timely and managerially relevant phenomenon.

Acknowledgment

This paper benefited from insightful comments of Bridget Hutter, Georg Schreyögg, David Seidl, Jörg Sydow, Arnold Windeler, and Jürgen Zentek on early drafts as well as challenging yet constructive comments of Joe Lampel.

Author's Note

Earlier versions of this paper were presented at the 2012 EGOS Colloquium in Helsinki, Finland; the European Academy of Management Meeting 2012 in Rotterdam, The Netherlands; and in two research seminars at the Freie Universität Berlin, Germany.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study received financial support from the Peter Pribilla Foundation.

References

Aigner, I. (2011). *Bundesministerin Aigner im Deutschen Bundestag zum EHEC-Ausbruch in Deutschland* [Federal minister Aigner in the German Bundestag regarding the EHEC outbreak in Germany]. Retrieved from http://www.bmelv.de/SharedDocs/Reden/2011/06-08-AI-AgrarministerkonferenzJuni11.html

Ärzte Zeitung. (2011a). *EHEC und das RKI - Behörde in der Kritik* [EHEC and the RKI—Public authority subject to criticism]. Retrieved from http://www.aerztezeitung.de/medizin/med_specials/ehec-2011/article/657699/ehec-rki-behoerde-kritik.html

Ärzte Zeitung. (2011b). *Nach EHEC: Rückenwind für die Nierenärzte* [Post EHEC: Support for nephrologists]. Retrieved from http://www.aerztezeitung.de/medizin/med_specials/ehec-2011/article/669482/nach-ehec-rueckenwind-nierenaerzte.html

Ärzte Zeitung. (2011c). *EHEC: Sprossen bislang alle negativ* [EHEC: Sprouts tested negative so far]. Retrieved from http://www.aerztezeitung.de/medizin/med_specials/ehec-2011/article/658074/ehec-sprossen-bislang-alle-negativ.html

Bansal, P., & Clelland, I. (2004). Talking trash: Legitimacy, impression management, and unsystematic risk in the context of the natural environment. *Academy of Management Journal*, *47*, 93-103.

Barley, S. R., & Tolbert, P. S. (1997). Institutionalization and structuration: Studying the links between action and institution. *Organization Studies*, *18*, 93-117.

Baum, J. A. C., & Dahlin, K. B. (2007). Aspiration performance and railroads' patterns of learning from train wrecks and crashes. *Organization Science*, *18*, 368-385.

BBC. (2011). *German cucumber E.coli outbreak "may last months."* Retrieved from http://www.bbc.co.uk/news/world-europe-13624554

Bechky, B. A., & Okhuysen, G. A. (2011). Expecting the unexpected? How SWAT officers and film crews handle surprises. *Academy of Management Journal*, *54*, 239-361.

Beneker, C. (2011). *Föderalismus in der Kritik: EHEC macht nicht an Grenzen halt* [Federalism subject to criticism: EHEC does not stop at borders]. Retrieved from http://www.aerztezeitung.de/medizin/med_specials/ehec-2011/article/657573/foerderalismus-kritik-ehec-macht-nicht-grenzen-halt.html

Berthod, O., Müller-Seitz, G., & Sydow, J. (2012). Ad hoc-Koordination im Krisenfall [Ad hoc coordination in crisis]. *Zeitschrift Führung + Organisation*, *81*, 230-236.

Berthod, O., Müller-Seitz, G., & Sydow, J. (in press). Interorganizational crisis management. In A. Thießen (Ed.), *Handbuch integriertes Krisenmanagement*. Berlin, Germany: Springer.

Bielaszewska, M., Mellmann, A., Zhang, W., Köck, R., Fruth, A., Bauwens, A., & Karch, H. (2011). Characterisation of the Escherichia coli strain associated with an outbreak of haemolytic uraemic syndrome in Germany, 2011: A microbiological study. *The Lancet*, *11*, 671-676.

Birkland, T. A. (1998). Focusing events, mobilization, and agenda setting. *Journal of Public Policy*, *18*, 53-74.

Boin, A., & Schulman, P. (2008). Assessing NASA's safety culture: The limits and possibilities of high-reliability theory. *Public Administration Review*, *68*, 1050-1062.

Bundesamt für Verbraucherschutz und Lebensmittelsicherheit. (2011). *Kurzinformation über die Arbeit der Task Force EHEC* [Task Force at the BVL searches for the source of the EHEC outbreak]. http://www.bvl.bund.de/DE/08_PresseInfothek/01_FuerJournalisten/01_Presse_und_Hintergrundinformationen/01_Lebensmittel/2011/2011_06_07_EHEC_Task_Force.html

Coombs, W. T. (2007). Protecting organization reputations during a crisis: The development and application of situational crisis communication theory. *Corporate Reputation Review*, *10*, 163-176.

Cowen, A. P., & Cowen, S. S. (2010). Rediscovering communities: Lessons from the hurricane Katrina crisis. *Journal of Management Inquiry*, *19*, 117-125.

Dowling, S., Walker, P., & Gabbatt, A. (2011). *E coli outbreak: EU health chief attacks Germany*. Retrieved from http://www.guardian.co.uk/world/2011/jun/07/e-coli-outbreak-eu-emergency-talks

Dreising, S. (2011). *EHEC: Scientists of Münster identify genome sequence of a comparable strain of the year 2001*. Retrieved from http://www.innovations-report.de/html/berichte/biowissenschaften_chemie/ehec_scientists_muenster_identify_genome_sequence_a_176484.html

ECDC. (2011). New European research project to respond to unexpected epidemic threats such as Escherichia coli. *Eurosurveillance*, *16*(32), 1.

Ehrenstein, C. (2011). *Koalition richtet Taskforce für Lebensmittelkrisen ein* [Coalition launches task force for food-borne disease outbreaks]. Retrieved from http://www.morgenpost.de/printarchiv/seite3/article1720759/Koalition-richtet-Taskforce-fuer-Lebensmittelkrisen-ein.html

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, *32*, 543-576.

Elger, K., Friedmann, J., Fröhlingsdorf, M., Hackenbroch, V., Latsch, G., Thadeusz, F., & Verbeet, M. (2011). Paradies für Keime [Paradise for germs]. *Der Spiegel*, *11*, 118-119.

Elliott, D., & Smith, D. (2006). Cultural readjustment after crisis: Regulation and learning from crisis within the UK soccer industry. *Journal of Management Studies*, *43*, 289-317.

Elsbach, K. D., Sutton, R. I., & Principe, K. E. (1998). Averting expected challenges through anticipatory impression management: A study of hospital billing. *Organization Science*, *9*, 68-86.

Engels, D. (2011, Oktober).*Organisation des gesundheitlichen Verbraucherschutzes (Schwerpunkt Lebensmittelsicherheit)* [Organization of consumer protection (focus food security)]. Retrieved from http://www.bmelv.de/SharedDocs/Downloads/Ernaehrung/2011-248-PM_BWV-Gutachten.pdf?__blob=publicationFile

Faber, M. (2011). Informationen zum EHEC-/HUS-Ausbruchsgeschehen von Mai bis Juli 2011 in Deutschland – Ende des Ausbruchs [Translation of the title: Information concerning the EHEC/HUS outbreak from May to July 2011 in Germany—End of the outbreak]. *Epidemiologisches Bulletin*, *31*: 295-296.

Federal Government. (2011). *EHEC Task Force als feste Sonderkommission* [EHEC Task Force as permanent special investigative team]. Retrieved from http://www.bundesregierung.de/nn_774/Content/DE/Artikel/2011/08/2011-08-03-ehec.html

Federal Institute for Risk Assessment; Federal Office of Consumer Protection and Food Safety; Robert Koch Institute. (2011). *EHEC: Current state of knowledge concerning illnesses in humans*. Retrieved from http://www.bfr.bund.de/en/press_information/2011/16/ehec__current_state_of_knowledge_concerning_illnesses_in_humans-70978.html

Foodwatch. (2011). *Foodwatch fights for consumers' rights*. Retrieved from http://foodwatch.de/english/index_ger.html

Frank, C., Faber, M. S., Askar, M., Bernard, H., Fruth, A., Gilsdorf, A., & Werber, D. (2011). Large and ongoing outbreak of haemolytic uraemic syndrome, Germany, May 2011. *Eurosurveillance*. Retrieved from http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19878

Giddens, A. (1979). *Central problems in social theory: Action, structure and contradiction in social analysis*. London, England: Macmillan.

Giddens, A. (1984). *The constitution of society*. Cambridge, MA: Polity Press.

Giddens, A. (1990). *The consequences of modernity*. Cambridge, MA: Polity Press.

Giddens, A. (1991). *Modernity and self identity: Self and society in the late modern age*. Cambridge, MA: Polity Press.

Giddens, A. (2011). *The politics of climate change*. Cambridge, MA: Polity Press.

Handelsblatt. (2011). *Handel fordert Ehec-Entschädigung* [Retailing demands compensation]. Retrieved from http://www.handelsblatt.com/unternehmen/handel-dienstleister/handel-fordert-ehec-entschaedigung/4301674.html

Harding, D. J., Fox, C., & Mehta, J. D. (2002). Studying rare events through qualitative case studies. *Sociological Methods & Research*, *31*, 174-217.

Haunschild, P. R., & Rhee, M. (2004). The role of volition in organizational learning: The case of automotive product recalls. *Management Science*, *15*, 1545-1560.

Hopkins, A. (1999). The limits of normal accident theory. *Safety Science*, *32*, 93-102.

Hucklenbroich, C. (2011). *Es wird häufiger Krisen geben* [There will be more crises]. FAZ online, Retrieved from http://www.faz.net/aktuell/wissen/medizin/andreas-hensel-im-interview-es-wird-haeufiger-krisen-geben-12017608.html

Jähn, C. (2011, December 13). *EHEC-Forschung wird mit 1,23 Millionen Euro gefördert-Krankheitsbilder und Langzeitfolgen im Fokus* [EHEC research will be funded with 1,23 Million Euros—Focusing upon disease patterns and long-term effects]. Hamburg, Germany: Universitätsklinikum Hamburg-Eppendorf.

Jansen, A., & Kielstein, J. T. (2011). The new face of enterohaemorrhagic Escherichia coli. *Eurosurveillance*, *16*, 1.

Jarzabkowski, P. (2008). Shaping strategy as a structuration process. *Academy of Management Journal*, *51*, 621-650.

Karch, H. (2011). *Einen so schweren Ehec-Ausbruch hat es noch nicht gegeben* [There has never been such a severe EHEC outbreak before]. Retrieved from http://www.zeit.de/wissen/gesundheit/2011-05/ehec-bakterien-darmerkrankungen-interview

Knight, F. H. (1921). *Risk, uncertainty and profit*. Chicago, IL: University of Chicago Press.

Krause, G., Frank, C., Gilsdorf, A., Mielke, M., Schaade, L., Stark, K., & Burger, R. (2013). Der HUS-Ausbruch 2011 in Deutschland. Herausforderungen für den Infektionsschutz: Was sollte künftig verbessert werden? [The HUS-outbreak 2011 in Germany. Challenges for the Infection Protection Act: What can be improved in the future?]. *Bundesgesundheitsblatt*, *56*, 56-66.

Lampel, J., & Meyer, A. D. (2008). Field-configuring events as structuring mechanisms: How conferences, ceremonies, and trade shows constitute new technologies, industries, and markets. Journal of Management Studies, *45*, 1025-1035.

Lampel, J., Shamsie, J., & Shapira, Z. (2009). Experiencing the improbable: Rare events and organizational learning. *Organization Science*, *20*, 835-845.

Lampel, J., & Shapira, Z. (2001). Judgmental errors, interactive norms, and the difficulty of detecting strategic surprises. *Organization Science*, *12*, 599-611.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, *24*, 691-710.

La Porte, T. (1996). High reliability organizations: Unlikely, demanding and at risk. *Journal of Contingencies and Crises Management*, *4*, 60-71.

Laursen, L. (2011). E. Coli crisis opens door for Alexion drug trial. *Nature Biotechnology*, *29*, 671.

Lindenbaum, S. (1979). *Kuru sorcery: Disease and danger in the New Guinea Highlands*. Palo Alto, CA: Mayfield.

Lindenbaum, S. (2001). Kuru, prions, and human affairs: Thinking about epidemics. *Annual Review of Anthropology*, *30*, 363-385.

Madsen, P. M., & Desai, V. (2010). Failing to learn? The effects of failure and success on organizational learning in the global orbital launch vehicle industry. *Academy of Management Journal*, *53*, 451-476.

Marcus, A., & Nichols, M. (1999). On the edge: Heeding warnings of unusual events. *Organization Science*, *10*, 482-499.

Michel, A. A. (2007). A distributed cognition perspective on newcomers' change processes: The management of cognitive uncertainty in two investment banks. *Administrative Science Quarterly*, *52*, 507-557.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.

Moss, T. H., & Sills, D. L. (1981). *The Three Mile Island accident: Lessons and implications*. New York: New York Academy of Sciences.

Moynihan, D. P. (2008). Learning under uncertainty: Networks in crisis management. *Public Administration Review*, *68*, 350-365.

Müller-Seitz, G., & Macpherson, A. (in press). Learning during uncertainty as a "war for meaning"-The Case of the German E. coli Outbreak in 2011. *Management Learning*.

Müller-Seitz, G., & Schüßler, E. (2013). From event management to the management of events—A process perspective. *Managementforschung*, *23*, 193-226.

Munir, K. A. (2011). Financial crisis 2008-2009: What does the silence of institutional theorists tell us? *Journal of Management Inquiry*, *20*, 114-117.

Perin, C. (2006). *Shouldering risks: The culture of control in the nuclear power industry*. Princeton, NJ: Princeton University Press.

Perrow, C. (1984). *Normal accidents*. New York, NY: Basic Books.

Perrow, C. (2011). *The next catastrophe: Reducing our vulnerabilities to natural, industrial, and terrorist disasters*. Princeton, NJ: Princeton University Press.

Prüfer-Storcks, C. (2011, May 27). Germany e.coli bacteria in cucumbers kills four. *BBC News* [Translation by the BBC].

Quarantelli, E. L. (1954). The nature and conditions of panic. *American Journal of Sociology*, *60*, 267-275.

Reason, J. (1990). *Human error*. Cambridge, MA: Cambridge University Press.

Rissland, J., Kielstein, J. T., Stark, K., Wichmann-Schauer, H., Stümpel, F., & Pulz, M. (2013). The EHEC O104:H4 Outbreak in Germany 2011-lessons learned? *Gesundheitswesen*, *75*, 184-189.

Robert Koch Institute. (2010). *Das Robert Koch-Institut - das Public Health Institut für Deutschland* [The Robert-Koch Institute—The public health institute for Germany]. Berlin, Germany: Author.

Robert Koch Institute. (2011). *EHEC/HUS O104:H4: The outbreak is considered to be over*. Retrieved from http://www.rki.de/EN/Home/PM_EHEC.html

Robert Koch Institute. (2012). *Abschlussbericht zum großen Ausbruch von Norovirus-Gastroenteritis im September-Oktober 2012* [Final report regarding the large-scale norovirus-gastroenteritis outbreak in September-October 2012]. Berlin, Germany: Author.

Roberts, K. H. (1990a). Managing high reliability organizations. *California Management Review*, *32*, 101-113.

Roberts, K. H. (1990b). Some characteristics of one type of high reliability organization. *Organization Science*, *1*, 160-176.

Rosenberg, C. E. (1989). What is an epidemic? AIDS in historical perspective. *Daedalus*, *118*, 1-17.

Rosenberg, C. E. (1992). *Explaining epidemics and other studies in the history of medicine*. Cambridge, MA: Cambridge University Press.

Sagan, S. D. (1993). *The limits of safety: Organizations, accidents, and nuclear weapons*. Princeton, NJ: Princeton University Press.

Schielke, A., & Stark, K. (2012). Ergebnisse des Workshops: "Experiences from the STEC O104:H4 outbreak in Germany and research needs for STEC." Epidemiologisches Bulletin, 12, 71-74.

Scott, W. (1993). The management of crises and tribulations. *Journal of Management Inquiry*, *2*, 184-189.

Shrivastava, P. (1987). *Bhopal: Anatomy of a crisis*. Cambridge, MA: Ballinger.

Shrivastava, S., Sonpar, K., & Pazzaglia, F. (2009). Normal accident theory versus high reliability theory: A resolution and call for an open systems view of accidents. *Human Relations*, *62*, 1357-1390.

Snook, S. A. (2000). *Friendly fire: The accidental shootdown of U.S. Black Hawks over Northern Iraq*. Princeton, NJ: Princeton University Press.

Spiegel online. (2011). *Kliniken fordern Entschädigung für Ehec* [Hospitals demand compensation for EHEC]. Retrieved from http://www.spiegel.de/wirtschaft/soziales/kosten-der-epidemie-kliniken-fordern-entschaedigung-fuer-ehec-a-767359.html

Sprehe, D. (2011). *Deutschland verteidigt Vorgehen in der EHEC-Krise* [Germany defends its course of action in the EHEC crisis]. Retrieved from http://www.tagesschau.de/ausland/eheceu100.html

Sprenger, M. (2011, September 17). *Understanding the 2011 EHEC/STEC outbreak in Germany*. Presentation at the ICAAC Conference, Chicago, IL. Retrieved from http://www.ecdc.europa.eu/en/aboutus/organisation/Director%20Speeches/201109_MarcSprenger_STEC_ICAAC.pdf

Starbuck, W. H. & Farjoun, M. (Eds.). (2005). *Organization at the limit: Lessons from the Columbia Disaster*. Malden, MA: Blackwell Publishing.

Starbuck, W. H., & Milliken, F. (1988). Challenger: Changing the odds until something breaks. *Journal of Management Studies*, *25*, 319-340.

Sydow, J., Müller-Seitz, G., & Provan, K. (2013). Managing uncertainty in alliances and networks: From governance to practice. In T. K. Das (Ed.), *Managing knowledge in strategic alliances* (pp. 1-43). Charlotte, NC: Information Age Publishing.

Sydow, J., & Windeler, A. (1998). Organizing and evaluating interfirm networks: A structurationist perspective on network processes and effectiveness. *Organization Science*, *9*, 265-284.

Tagesschau.de.(2011). *Von Kompetenzen und Grenzen*. Retrieved from http://www.tagesschau.de/inland/eheczustaendigkeiten100.html

Tamuz, M., & Harrison, M. I. (2006). Improving patient safety in hospitals: Contributions of high-reliability theory and normal accident theory. *Health Research & Educational Trust*, *41*, 1654-1676.

Tschiersky-Schöneburg, H. (2011). EHEC - und was dann? *Journal of Consumer Protection and Food Safety*, *6*, 409-410.

Turner, B. A. (1978). *Manmade disasters*. London, England: Wykeham Press.

Ungson, G. A. (1998). When interpretations collide: The case of Asia's financial crisis. *Journal of Management Inquiry*, *7*, 321-341.

Vaughan, D. (1996). *The challenger launch decision: Risky technology, culture, and deviance at NASA*. Chicago, IL: University of Chicago Press.

Weick, K. E. (1969). *The social psychology of organizing*. Reading, MA: Addison-Wesley.

Weick, K. E. (1995). *Sensemaking in organizations*. Thousand Oaks, CA: Sage.

Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly*, *38*, 357-381.

Weick, K. E., & Sutcliffe, K. M. (2007). *Managing the unexpected: Resilient performance in an age of uncertainty* (2nd ed.). San Francisco, CA: Jossey-Bass.

Weick, K. E., Sutcliffe, K., & Obstfeld, D. (1999). Organizing for high-reliability: Processes of collective mindfulness. In R. Sutton & B. Staw (Eds.), *Research in organizational behavior* (Vol. 1, pp. 81-123). Stanford, CA: JAI Press.

Weidmann, K. (1999). Die heimliche Seuche: Der Killer-Keim EHEC. Chancen und Probleme einer Recherche im Ausland [The lurking epidemic: The killer germ EHEC. Chances and problems of an investigation abroad]. In T. Leif (Ed.), *Leidenschaft: Recherche: Skandal-Geschichten und Enthüllungs-Berichte* [Passion: Investigation: Scandalous reports and revealing reports] (2nd ed., pp. 153-160). Opladen, Germany: West-deutscher Verlag.

Yin, R. K. (2009). *Case study research* (4th ed.). Thousand Oaks, CA: Sage.

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