International Journal of Medical Informatics 104 (2017) 65–73

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Research Paper

Dealing with uncertainty when using a surveillance system

Gaëtan Texier[a,b,*], Liliane Pellegrin[b,c], Claire Vignal[d], Jean-Baptiste Meynard[b,c], Xavier Deparis[b,c], Hervé Chaudet[b]

[a] Centre Pasteur du Cameroun, BP 1274, Yaoundé, Cameroon
[b] UMR 912/SESSTIM – INSERM/IRD/Aix-Marseille University/Faculty of Medicine, 27 Bd Jean Moulin, 13385 Marseille, France
[c] French Armed Forces Center for Epidemiology and Public Health (CESPA), Camp de Sainte Marthe, 13568 Marseille, France
[d] Center for Research in the Psychology of Cognition, Language and Emotion (PsyCLE), 29 avenue Robert Schuman, 13621 Aix-en-Provence, France

ARTICLE INFO

Keywords:
Disease surveillance system
Outbreak
Uncertainty
Decision support system
Expert decision making

ABSTRACT

Introduction: Epidemiologists manage outbreak identification and confirmation by means of a "situation diagnosis", which involves validating (or invalidating) an alarm (signal identified as abnormal) as an alert (a real, characterized outbreak) and proposing the first countermeasures. This work investigates how uncertainty is materialized during this stage, and how experts develop strategies to address this uncertainty with the help of an early warning system.
Methods: We built an experiment using a simulation platform with a scenario involving both a natural and an intentional outbreak. Observations of expert activities were recorded and formalised using a specific task analysis method. These formatted data were then categorized by applying RAWFS (*Reduction- Assumption – Weighing – Forestalling- Suppression*) heuristics.
Results: We quantified uncertainty and the mechanisms involved. During the situation diagnosis, two sorts of uncertainty were characterized: practice-imposed uncertainty and situation-imposed uncertainty. We did not find either weighing pros and cons or suppression strategies in this area of expertise, but highlight the predominance of coping strategies that relied on reduction (66,4%) and assumption-based reasoning. We observed a predominance of the phone (89%) to cope with uncertainty and among electronic tools, the surveillance system plays a major role (69% of cases) and is mainly used in reduction strategies. We detail tools and systems used to support experts in their coping strategy.
Conclusion: We confirmed that a surveillance system must include different features that provide relevant information to help users reduce uncertainty and thus support their decision making. In that perspective, the flow diagram and proposal presented in this study can help prioritize the necessary changes to surveillance system design.

1. Introduction

Syndromic surveillance is "the real-time (or near real-time) collection, analysis, interpretation, and dissemination of health-related data to enable the early identification of the impact (or absence of impact) of potential human or veterinary public health threats that require effective public health action" [1]. A goal of syndromic surveillance is to identify outbreaks [2] as soon as possible, in order to reduce health impacts by decreasing response times and improving their effectiveness.

Syndromic surveillance is supported by specific, tailored information systems [3–5]. These systems provide accurate information and knowledge to support outbreak detection and entail a strong interaction between these systems and their users. A disease surveillance network could be considered as a socio-technical system, which associates geographically distant medical stakeholders (up to a few thousand people in different specialties) with dedicated systems and technical tools (phone, satellite, digital documentation, etc.) working together to detect and manage outbreak situations [6,7].

According to Chaudet et al., epidemiologists manage outbreak identification and confirmation by means of a "situation diagnosis" [2,8], which involves validating (or invalidating) an alarm (signal identified as aberrant or abnormal) as an alert (a real, characterized outbreak) and proposing the first countermeasures.

Outbreaks surveillance concerns a complex healthcare situation, which involve a wide range of human, biological or environmental (and

* Corresponding author at: Centre Pasteur du Cameroun, BP 1274, Yaoundé, Cameroon.
E-mail addresses: gaetex1@gmail.com (G. Texier), liliane.pellegrin_chaudet@univ-amu.fr (L. Pellegrin), claire.vignal@orange.fr (C. Vignal), jb.meynard@wanadoo.fr (J.-B. Meynard), xavier.deparis@wanadoo.fr (X. Deparis), herve.chaudet@univ-amu.fr (H. Chaudet).

http://dx.doi.org/10.1016/j.ijmedinf.2017.05.006
Received 9 March 2016; Received in revised form 14 February 2017; Accepted 8 May 2017
1386-5056/

many others ones) components, featured by interrelated, non-decomposable and non-linear behaviours [9], Each of them could be considered also as a complex processes with unexpected actions and unknowns, which are possible sources of uncertainty for expert decision-making. Concerning early warning surveillance, the nature of collected data, which are syndromic and not pathogen-specific, should increase the uncertainty level that these epidemiologists face. This is due to the lack of specificity of the provided data, which complicates their analysis of the situation. As others critical and complex medical activities (emergency, surgery, patient resuscitation.), four components have to be considered [10,11]: multiple and/or concurrent tasks, uncertainty to cope with, changing plans and compressed work procedures due to high workload and severe time and context pressures.

If we look at the overall decision context of outbreak management and, more specifically syndromic surveillance is a collective and complex public health task, described as “situation diagnosis” implying information acquisition and transmissions, the building of an accurate representation of the situation and expert decision-making processes. Specific tools, syndromic surveillance systems, have been designed to provide an adapted computational awareness workspace [11,12]. But questions remain unknown about how experts are really helped by theses systems or how these technological innovations assist even enhance epidemiological judgement and decision-making. To answer such question, we needs first to understand how experts’ activities occur in this “working with technology” context [13] especially how they deal with its uncertainty elements during an outbreak alert.

Classical decision making models initiated in statistics and economics areas have formalised decisions under uncertainty as rational choices upon possible outcomes that are unknown, which are bounded to expected values or benefits for the decision-maker [14]. The basic assumptions of this theory called “expected utility theory”, are firstly, that decisions are seen as rational choices and secondly, that these choices are based upon maximising an expected utility of the possible courses of actions. Seen as a possible theory of decision-making by “real” people in current-life, the expected utility approach has been confronted to experimental data, initially by Tversky and Kahneman [15]. They found biases, called “cognitive biases”, resulting from a systematic deviation between human judgments and the expected utility model. These authors explain these cognitive biases by the fact that human judgments are processed according to heuristic rules. From these works, a new approach focusing on human specificities has emerged which underlines the importance of the human-centred decision-making models. The Naturalistic Decision Making approach (NDM), follows this approach focusing on situation perception, recognition and assessment prior to choosing a course of action occurring in real-world settings [16]. It focuses on how professionals with long-term experience make decisions in complex and safety-critical environments (industrial systems, transports, defense, healthcare…).

Healthcare activities and technical environments could be described as such complex work systems [17] whose main features are time pressure, dynamic environments, ill-structured problems, uncertainty, vague goals, high stakes, team and organizational constraints. NDM explores situations of diagnosis, planning, supervision and control processes as well as collaboration and cooperation both between humans, and between humans and systems. Its application fields covers the design and use of technological, digital environments (information systems, decision support systems, communication systems). Finally, NDM provides an interesting framework to study and describe decision-making in health care practices and situations [18,19].

According to Han & als [20], we consider that uncertainty is a common and important topic in medical domains because it pervades medical activities and decision-making. As previously described in this introduction, we hypothesize that in outbreak alert, the experts subjective experience of uncertain events is a major element of cognitive activities performed to manage the situation. Lipshitz and Strauss [21] propose a naturalistic model of decision making under uncertainty, the RAWFS heuristic (Reduction, Assumption based reasoning, Weighing pros and cons, Forestalling, and Suppression), describing how decision makers reduce, acknowledge or suppress uncertainty in order to cope with it. They define uncertainty (in the context of action) as that which “impacts decision-making as a sense of doubt that blocks or delays action.”

This work investigates how uncertainty is materialized during the management of an outbreak, and how experts build strategies to address such uncertainty with the help of an early warning system called ASTER [8]. In the context of a situation diagnosis, our study aims at quantifying the different types of uncertainty and identifying pertinent tools actually used, or which could be used, to reduce that uncertainty.

2. Materials and methods

2.1. The process of disease surveillance

To identify steps in surveillance and information flow management in order to facilitate observation collection, coding and analysis, we proposed a model of the surveillance process as a flow diagram according to cognitive situation awareness model [22,23].

Using this description format was first justified by revealing the underlying structure of the decision elements and their interaction for a disease surveillance seen as a dynamic control and complex task. Secondly, we follow also an operational argument, which was to find solutions for improving data management in disease surveillance systems to assist expert decision-making.

To implement this decision flow, we carried out several face-to-face interviews with disease surveillance experts to identify main tasks elements and their organisation using Sebillotte's Hierarchical Planning method [24] and MAD task description (Analytic Method for Task Description: MAD) [25]. In knowledge engineering domain, these methods are tailored to provide, at various levels of detail, an accurate representation of system users, their tasks and activities.

2.2. The RAWFS

According to Lipshitz and Strauss [21], uncertainty as “the doubts that delay or block an action” can be specified in terms of two main dimensions, issues (domains) and sources (or types). Issues describe what decision makers are uncertain about and sources are specific types of uncertainty that decision makers deal with. In the context of naturalistic decision making, they described three basic source of uncertainty: Lack of information, inadequate understanding and conflict. They also proposed five different heuristics (RAWFS) completed in 2007 [26], which are used by experts facing uncertainties in complex situations:

- *Reduction (R)*: reducing uncertainty or removing it altogether (for example through information seeking, collecting additional information). This strategy includes four different sub-strategies (delaying action, active information search, relying on SOPs − *standard operating procedure*, prioritizing).
- *Assumption-based reasoning (A)*: relies on knowledge and imagination to fill gaps in, or make sense of, factual information. Lack of information is often handled using this tactic. This strategy also includes four sub-strategies: (planning, mental rehearsal, mental simulation, conjecturing).
- *Weighing pros and cons* (W): managing rival options and arbitrating conflict between various alternatives after comparing them.
- *Forestalling (F):* prepares a course of action to counter potential negative contingencies (e.g., building reserves or preparing a worst case option).
- *Suppression (S):* manages uncertainty by ignoring it or by taking a