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Published in:
Biosecurity and Bioterrorism

DOI:
10.1089/bsp.2012.0083

Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

Link to publication

Citation (APA):
Andersson, M. G., Tomuzia, K., Löfström, C., Appel, B., Bano, L., Keremidis, H., ... Barker, G. C. (2013). Separated by a Common Language: Awareness of Term Usage Differences Between Languages and Disciplines in Biopreparedness. Biosecurity and Bioterrorism, 11(Supplement 1), S276-S285. DOI: 10.1089/bsp.2012.0083

Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science
Volume 11, Supplement 1, 2013 © Mary Ann Liebert, Inc.
DOI: 10.1089/bsp.2012.0083

Separated by a Common Language: Awareness of Term Usage Differences Between Languages and Disciplines in Biopreparedness

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Preparedness for bioterrorism is based on communication between people in organizations who are educated and trained in several disciplines, including law enforcement, health, and science. Various backgrounds, cultures, and vocabularies generate difficulties in understanding and interpretating terms and concepts, which may impair communication. This is especially true in emergency situations, in which the need for clarity and consistency is vital. The EU project AniBioThreat initiated methods and made a rough estimate of the terms and concepts that are crucial for an incident, and a pilot database with key terms and definitions has been constructed. Analysis of collected terms and sources has shown that many of the participating organizations use various international standards in their area of expertise. The same term often represents different concepts in the standards from different sectors, or, alternatively, different terms were used to represent the same or similar concepts. The use of conflicting terminology can be problematic for decision makers and communicators in planning and prevention or when handling an incident. Since the CBRN area has roots in multiple disciplines, each with its own evolving terminology, it may not be realistic to achieve unequivocal communication through a standardized vocabulary and joint definitions for words from common language. We suggest that a communication strategy should include awareness of alternative definitions and ontologies and the ability to talk and write without relying on the implicit knowledge underlying specialized jargon. Consequently, cross-disciplinary communi-

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cation skills should be part of training of personnel in the CBRN field. In addition, a searchable repository of terms and definitions from relevant organizations and authorities would be a valuable addition to existing glossaries for improving awareness concerning bioterrorism prevention planning.

Bioterrorism preparedness is a cross-sectorial and international challenge, and there is a particular need to harmonize terminology to obtain an improved level of interoperability between various sectors such as law enforcement and public and animal health.[1] Previous efforts to integrate safety and security[2] resulted in the Laboratory Biorisk Management Standard CWA 15793:2008.[3] Subsequent work by the European Commission (EC) concerning interoperability and standardization in security resulted in the European Security Research and Innovation (ESRIF) report,[4] which highlights the importance of integration and connectivity because of their very specific enabling role both within and between the security missions. Terminology, as part of communication, is an important aspect of integration and connectivity, particularly in relation to the delivery of specialized knowledge in a concentrated form[5] but also in relation to improved understanding and increased trust when communicating with people outside of a particular profession.[4] In relation to bioterrorism, misunderstandings initiated by multidisciplinary and multilingual communications can cause fatal problems.[4] Communication, and hence terminology, is often most crucial in stressful or crisis situations that require clarity, consistency, and simplicity. The lack of commonly accepted definitions for CBRN materials, threats, or incidents has been pointed out,[6] and during exercises and incidents it has been observed that uncertainties about definitions (eg, for bioterrorism and biocrime) may impair decision making and delay a coordinated response.[7] We cannot propose an absolute terminology or even a standardized subset of definitions, but in this article we aim to ensure that policymakers and other crucial CBRN personnel become aware of the pitfalls of assuming common linguistic and conceptual backgrounds for multinational and multidisciplinary communications concerning CBRN preparedness. We derive support for this awareness from examples of terms and definitions in current use, from consultation with terminology experts from other disciplines and from other relevant projects concerned with harmonized collections.

The relation between different terms and words in a language is referred to as an ontology.[8,9] An ontology can be defined as a formal explicit specification of a shared conceptualization; often it is an abstract model of relevant concepts shared by people and groups. The ontology might contain explicitly defined concepts and constraints for their use and is often machine readable.[10] Thus, an ontology defines the terms used to describe and represent an area of knowledge. However, in the absence of an explicit model, a shared understanding of the relation between concepts and lexical expressions (words or their combinations) may still exist within a group of people or organizations that regularly exchange messages and is of course essential for meaningful communication.

Following Mojtahed et al,[9] we refer to this shared conceptualization as an *implicit ontology.* However, implicit ontologies differ between languages and between members of various disciplines using the same language. Failures of communication can occur when the sender of a message, oral or written, incorrectly assumes that the receiver has the same implicit ontology. Similar problems are relevant in many disciplines, particularly business, military intelligence, medicine, and climatology. In many cases, the development of an appropriate and consistent set of terms and definitions used within a domain of interest—and relations among terms in a domain ontology[11-13]—has been a major step toward a better use of text sources. Identification, collection, and communication of a minimum set of terms and definitions often precedes more mechanistic analyses of representative sets of text sources or corpora, such as text analytics or natural language processing.[14] The problems associated with different ontologies have been extensively studied in military command and control projects such as IST-075[15] and IST-094[16] and within e-health,[17,18] where unambiguous interpretation and translation is vital. Strategies for designing linguistic support for risk communication, including the use of ontologies, was studied in the Wide Information Network project to improve Risk Management (WIN).[10,19]

The aim of this work was to initiate an appreciation of terms and definitions in relation to biosafety, biosecurity, and bioterrorism preparedness and to make policymakers aware of the pitfalls associated with common linguistic and conceptual assumptions. We do not generate an ontology for use with bioterrorism communications, but we have initiated a review of terms and definitions among several relevant disciplines that are pertinent in this domain, and we have compared common terms in a few languages. The development involves established expertise and communication methods from several European laboratories and agencies. In turn, this exercise highlights the potential for developments in linguistic theory and technical solutions to facilitate communication and translation. We hope that this work will be a platform for more targeted investigations of communication discontinuities and for the design of new tools and techniques that can support improved multilingual and multidisciplinary dialogue in relation to CBRN preparedness.

Materials and Methods

Collection of Terms and Definitions

Initially, proposals for terms were collected from a varied set of subject experts, as a structured, annotated list in a flat file. In the first instance, prospective terms were elicited based on their importance for communications between subject experts in distinct disciplines. The highest priority was given to terms used in communication between authorities and experts from different domains and to terms describing activities shared between different expert groups. Named entities (chemical names, microorganisms, organizations) and techniques used exclusively in a particular discipline were given lower priority for addition to the initial structure.

Each new record was broken down into several fields that included the term and its definition, a provisional description of the domain from which the term originated (eg, law, microbiology), synonyms, acronyms, and pointers to other related terms that could cause confusion. The provenance of the record and a source identifier were also encoded as separate fields. Translations and definitions in other languages were included when available (often direct translation by project members).

Construction of Term Database

To manage the collection of terms and facilitate searching and sorting of terms, the lists were imported into a MySQL 5.1.41 database (Oracle Corporation CA)[20] and made accessible online using php tools (phpMyAdmin 3.3.2).[21] The term relationships were included in separate fields for generic relations (IS A), partitive relations (PART OF), and associative relations (HAS TO DO WITH) (Figure 1). In addition, extra definitions and notes were assigned to additional fields. Almost all translations were in German or Swedish, and additional fields were added for translated terms, definitions, notes, and the like in both languages.

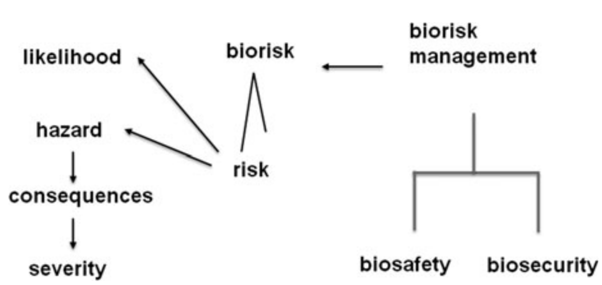

Figure 1. Example of concept diagram with generic (angle), partitive (grey tree), and associative (arrow) relations. The concepts *biosafety* and *biosecurity* are PART OF *biorisk management* which HAS TO DO WITH *biorisk.* The concept *Biorisk* IS A *risk,* which in turn HAS TO DO WITH the concepts *hazard, likelihood.* Finally, *hazard* HAS TO DO WITH *consequences,* which in turn HAS TO DO WITH severity.

Concept Analysis and Terminology Workshop

Further analysis of terms was performed with assistance from the Swedish Centre for Terminology in Solna, Sweden (TNC).[22] The aim was to find intentional definitions—that is, definitions specifying the necessary and sufficient conditions that delimit a concept. The first step was to visualize the relation between concepts using generic, partitive, and associative relations as exemplified in Figure 1. Following advice from TNC, a workshop was held in which participants from different organizations sought to agree on joint definitions of concepts related to risk/threat/hazard and analysis/management thereof with the guidance of the terminologists.

Results and Discussion

Identified Glossaries

While compiling the list of terms and definitions in this study, numerous glossaries were identified that have been developed in various disciplines at national and international levels. At the EU level, the Inter-Active Terminology for Europe (IATE)[23] constitutes the EU interinstitutional terminology database. A shortcoming is that it lacks relevant definitions of many terms included in the domain of bioterrorism and biological hazards, as well as from important international and national organizations.

The first version of the CBRN glossary was launched in November 2012 under the direction of the EU Joint Research Centre in Ispra in cooperation with EUROPOL & DG HOME. This glossary is an information tool on chemical, biological, radioactive, and nuclear hazards for practitioners in protection and response, including police officers, paramedics, and firefighters. It contains general definitions of terms related to CBRN and associated material and is translated into 23 European languages.[24] While not specifically intended for communication between scientists, it can serve as a generic information database.

Relevant databases at a national level include the US Department of Homeland Security (DHS) risk lexicon,[25] the Australian Emergency Management (AEM) glossary,[38] the Lexicon of UK Civil Protection Terminology,[34] the glossary of the German Federal Office of Civil Protection and Disaster Assistance (BBK) "AusgewähltezentraleBegriffe des Bevölkerungsschutzes" ("Selected relevant terms in Civil Protection," 2011, available only in German), and the glossary of the German Federal Institute for Consumer Health Protection and Veterinary Medicine (BgVV) "GLOSSAR von Termini der Risikoanalyse" (approximately "Glossary of terms in risk analysis," 2001, available in German/English). As noted in Greciano and Budin,[19] glossaries related to risk are either monolingual or bilingual without language-specific definitions. A Multilingual and

Multimedia Glossary for Risk Management (MGRM)[27] was prepared within the WIN project.[28] This database, however, has little or no coverage of terms related to CBRN or crime fighting activities.

Identified Terms

The compound term database (October 23, 2012) constructed in this project contains 683 records or terms proposed by one or several parties. For some terms, definitions were obtained from more than one source. The number of entries with English definitions is 543, representing 401 distinct terms. Major sources of definitions were official documents from various institutions like the EC ($n=28$), the Codex Alimentarius Commission (CAC) of the Food and Agricultural Organization of the United Nations (FAO) ($n=110$), the International Union of Pure and Applied Chemistry (IUPAC) ($n=42$), ISO ($n=139$), NATO ($n=20$), Interpol ($n=13$), CEN/TC 275 WG6 ($n=13$), the International Vocabulary of Metrology (VIM) ($n=19$), the Association of Analytical Communities (AOAC) ($n=7$), the World Organisation for Animal Health (OIE) ($n=6$), Eurochem ($n=6$), DHS ($n=4$), the WHO laboratory biosecurity guidance ($n=4$), and various scientific publications.

Differences in Terminology Between Disciplines

Analysis showed that some of the terminology used by stakeholders involved in CBRN preparedness has its roots in disciplines and organizations that have a long history, while other terms are being created from common language or are redefined as the knowledge and practices in the field evolve. Moreover, the collected definitions range from very broad, exemplified by the definition of threat from DHS[25] that covers essentially every meaning of the word in natural language, to very narrow, exemplified by the definitions of hazard from CAC[29] or IUPAC,[30] which includes delimitation to food or chemical substances, respectively. The variation in definitions and in the concepts behind the terms is illustrated in the following examples.

Example: Risk, Threat, Hazard

Risk, threat, and *hazard* are commonly used terms in the CBRN field with varying definitions, but they are also familiar in other areas such as risk analysis. The analysis made by TNC indicated that *threat* is sometimes used as a synonym for *risk*. Similarly, the terms *hazard* and *risk* are often, incorrectly, thought to be synonyms.[31] Depending on the context, the term *risk* could refer to "the likelihood/probability of a harmful event,"[31] "a combination of probability and severity,"[32] or sometimes a "combination of threat, consequences and vulnerability."[51] A broad definition of *threat* is "natural or man-made occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment and/or property."[25] A concept analysis revealed that *threat* may actually refer to several concepts including (1) indicated threats, (2) intentional threats, and (3) natural threats and that different organizations use the term in different senses (ie, the "threat of an attack" or the "threat of negative growth"). The shift in emphasis is reflected in the following definitions that focus on the indication (*Threat 1*), intent (*Threat 2*), and crisis potential (*Threat 3*):

Threat 1: "An indication of possible violence, harm or danger and may include an indication of intent and capability" (National Incident Management System, NIMS[33]).

Threat 2: "Intent and capacity to cause loss of life or create adverse consequences to human welfare (including property and the supply of essential services and commodities), the environment or security."[34] "A related definition is: "Likelihood for an adverse event to occur, as an expression of intention to inflict evil, injury, disruption or damage."[35]

Threat 3: "The likelihood of occurrence of a hazard or event with a harmful effect. In contrast to risk, a threat is not related to the impact it may cause. In the context of public health, a threat is defined as a substance, condition or event, which by its presence has the potential to rapidly harm an exposed population, sufficiently lead to a major crisis."[24]

The ambiguity is also reflected in the term *threat assessment,* which is formally defined only in a security context, as, for example, "strategic-intelligence products that provide analysis of the capabilities, intentions, vulnerabilities and limitations of groups posing a crime or security threat."[36] However, in a public health dialogue, threat assessment is also used in a more general sense for assessing risks and vulnerabilities associated with threats (eg, to human health).

Example: Risk Assessment

Terms related to assessment and analysis of risk were found to be defined differently in standards from different organizations, including the OIE,[37] the CAC,[29] the CEN laboratory biorisk management standard,[3] the US DHS risk lexicon,[25] the AEM glossary,[38] the Lexicon of UK Civil Protection Terminology,[34] and the FAO biosecurity toolkit.[39] Some differences in definition are reflections of variation in methodology. For example, according to the CAC guidelines,[29,32] hazard identification is considered a part of risk assessment, whereas in OIE guidelines,[37] it is considered an independent component of risk analysis (Figure 2). In other contexts the overall process is analogous, but the terms *risk assessment* and *risk analysis* have been swapped, and *risk management* has been replaced by *risk evaluation* (Figure 2).

Example: Scientific Terminology

Terms and definitions connected to assessing, verifying, and reporting the performance of detection methods have

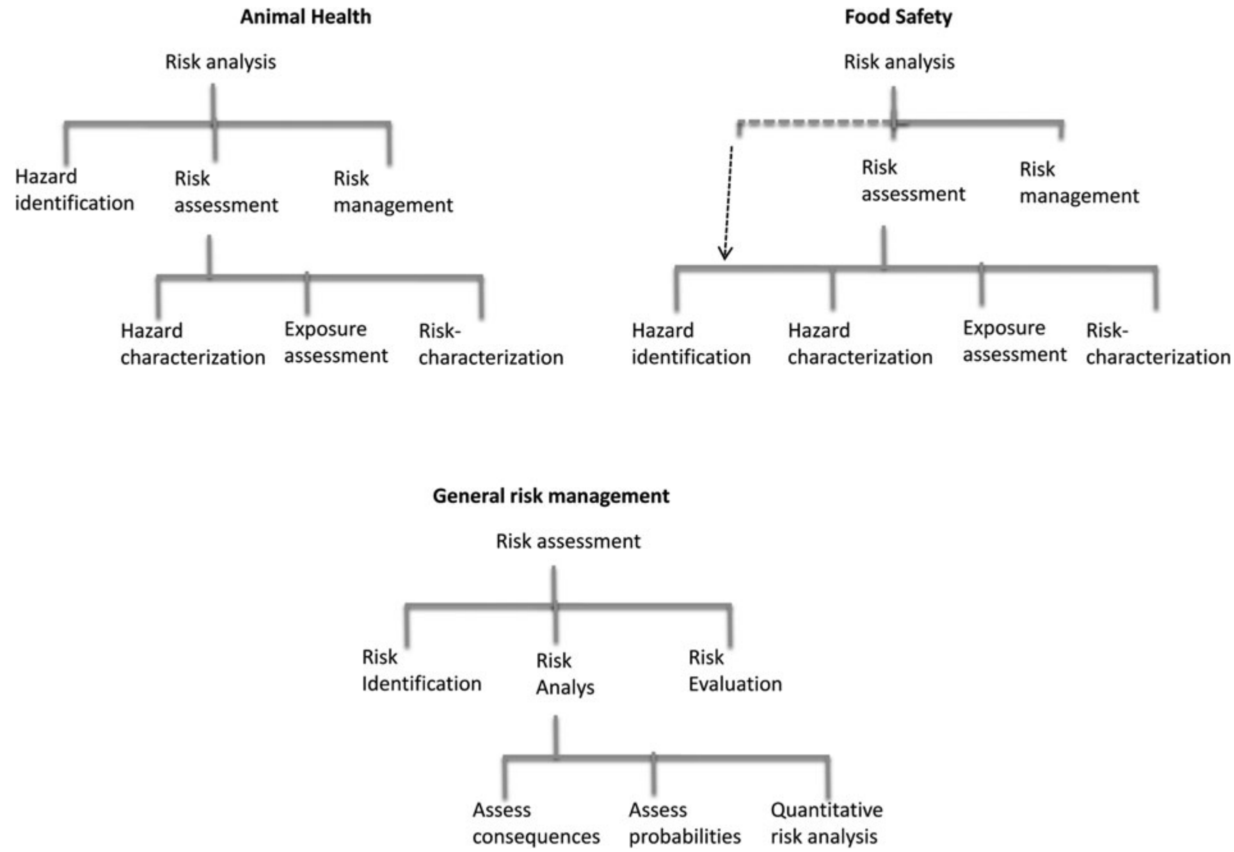

Figure 2. Result from comparative analysis of concepts/ontologies involving analysis and assessment of risks. The concept systems for animal health and food safety are based on (OIE 2011) and (CAC 2007a; CAC 2011), respectively. General risk management is a generalized concept system based on definitions from the DHS risk lexicon, AEM glossary, the Laboratory biorisk management standard, the UK cabinet office, and the Swedish Civil Contingency Agency.

been listed and defined in a large number of standards and publications.[40-44] Several examples were found in which the same term is used to denote different concepts in different contexts or where different terms are used for the same, or almost the same, concept (Table 1). In contrast to the terms related to risk, threat, and hazard, the terms related to detection generally refer to well-delimited concepts, although terminology and sometimes conceptualization differ between standards. Terms referring to microbiological and chemical agents are generally well defined, but confusion may occur due to the existence of multiple synonyms and acronyms. The same organism may also be named and defined differently depending on the context. Definitions may be based on the organism's position in the taxonomy (evolutionary tree), its phenotypic characteristics (morphology, chemistry), or on the clinical symptoms it causes.

Table 1. Example of Diversity of Terms in the Reporting of Performance of Detection Methods

	Performance Criteria of a Method				
Standard/guideline	*Detecting all variants of the target analyte*	*Not detecting nontarget analytes*	*No false positives in clinical setting*	*No false negatives in clinical setting*	*Lowest level where target is detected*
(ISO22174 2005)		Specificity			Detection limit/ Limit of detection
(ISO16140 2003)	Inclusivity	Exclusivity	Specificity	Sensitivity	
(ISO/TR13843 2001)	Sensitivity	Specificity		Sensitivity	
(CAC 2009)	Selectivity	Selectivity			Limit of detection
MIQE (Bustin et al. 2009)		Analytical specificity	Diagnostic specificity	Clinical sensitivity	Analytical sensitivity/ Limit of detection

For example, the pathogenic *Escherichia coli* (*E. coli*) STEC O104 that caused a major foodborne outbreak in Germany in 2011[45] may be classified as a "Shiga toxin producing *Escherichia coli* (STEC)," with the synonym of "verotoxigenic *Escherichia coli"* (VTEC) based on its capability to produce a toxin or as an "enterohemorrhagic *Escherichia coli"* (EHEC) based on the clinical symptoms it causes. Most of this information can be retrieved from medical ontologies such as SNOMED.[46] For anthrax, as an example, SNOMED lists the synonyms "Charbon," "infection due to *Bacillus anthracis,*" "milzbrand," and "splenic fever." Further, SNOMED includes the information that *Bacillus anthracis* is the causative agent with the synonym *Anthrax bacillus* and that it belongs to the *Bacillus cereus* group.

Definitions Versus Pragmatics

The rich variety of definitions reflects the fact that many organizations and professions have assigned term status to a set of general language words that have a special meaning in each specialist domain. For a bystander, it may be difficult to judge if the words encountered represent generally accepted terms or if they are part of local jargon. Terminologists from TNC assessed that not all entries in the term collection should be considered as valid terms. According to general terminology theory, definitions apply to concepts and a word becomes a term only when the concept behind the term is clearly delimited.[5] Among the words and terms analyzed in this project, the general approach to terminology was applicable mainly for terms representing physical objects (ie, substances, organisms, samples) and their measurements (concentrations, detection limits). In contrast, terms referring to objectives, procedures, or activities could often be defined in this way only as part of a specific protocol or method.

In the WIN project, it was observed that risk language is "action oriented," with a high frequency of predicative nouns expressing actions and processes (eg, assessment, awareness, coordination) but also with standardized expressions for particular situations that result in strong affinities between text and context.[19] In order to use and understand these terms correctly, the semantic information about a term (definition) must be accompanied by information on its pragmatics (defined as the meaning of an expression from a language in a specific context). In the definitions lists and glossaries identified above, such information is sometimes provided as comments. However, making the distinction between definitions and comments is the exception rather than the rule, and when alternative definitions are provided, the comments are often insufficient to allow the identification of a superior choice.

Differences in Terminology Between Languages

Translation between languages was found to constitute another source of confusion. Many terms used are created from words in natural language and have been translated word by word, causing confusion (Table 2). A special problem is that terminology and professional jargon in many languages often involves the adaptation of English words in a narrative sense and the loss of the associations from natural language. The narrative cognition of words often causes confusion when nonnatives are communicating in English, especially when the same word has been assigned term status in different contexts.

A typical example is the distinction between *security* and *safety*. In common usage, several languages use the same word for *safety* and *security,* and, as a consequence, the same term has been adopted for *biosafety* and *biosecurity* (Table 2). However, the term *food security* is now used widely (in English) with a very broad meaning (including food chain sustainability), and in many cases this includes *food*

Table 2. Example of Relation Between Terms from Different Languages[a]

	Preventing unintentional release: containment, technologies, and practices	*Preventing intentional actions: Access/control/ security procedures*	*Scientific assessment of risk by expert body (eg, in food safety, animal health)*	*Acute/ad hoc assessment of risk (eg, in laboratory, at a crime scene)*	*Indication of threat (eg, a spoken threat/ threat-ening someone)*	*Intentional threat: likelihood for an adverse event as an expression of intention*	*Natural threat: substance, condition, or event, with potential to rapidly harm a population*
En	Biosafety Biosecurity[b]	Biosecurity[b]	Risk assessment	Risk assessment	Threat	Threat	Threat
It	Biosicurezza	Bioprotezione (Biosicurezza)	Valutazione del Rischio	Valutazione del rischio	Minaccia	Minaccia	Minaccia (naturale)
De	Biosicherheit	Biosicherheit	Risikobewertung	Risikoabschätzung	Drohung (Androhung)	Bedrohung	Gefahr
Sw	Biosäkerhet	Biosäkerhet (bioskydd)	Riskvärdering (Riskbedömning)	Riskbedömning	Hot	Hot (Hotbild)	Hot
Nl	Biosafety	Biosecurity[b]	Risicobeoordeling	Risico inschatting	Dreiging	Bedreiging	Gevaar
Fr	Sécurité biologique	Sûreté biologique ou biosécurité	Evaluation du risque	Evaluation du risque	Danger	Danger	Danger
Dk	Biosikkerhed	Biosikring	Risikovurdering	Trussels-vurdering	Trussel	Trussel	Trussel

[a]The languages included are English (En), Italian (It), German (De), Swedish (Sw), Dutch (Nl), French (Fr), and Danish (Dk).

[b]The English term *Biosecurity* can be used specifically for the protection of biological agents from unauthorized use[35] or in a more general sense dealing with intentional as well as unintentional events.(eg, FAO2007). Biosecurity is sometimes also used in the meaning of preventing the introduction and spreading of pathogenic bacteria and viruses on a farm, including cleaning and disinfection.

safety.[35,39,47] This means that a particular relationship between *food security* and *food safety* in English is masked by linguistic relationships in some other languages. Perhaps surprisingly, there are many differences between English usage in the UK and in the USA; these differences are even more apparent in relation to bioterrorism and biological hazards because of the recent emphasis placed on bioterrorism by the US DHS. This counterintuitive disparity is the origin of our title—"separated by a common language"—referring to the UK and the USA; the quote is variously attributed to Oscar Wilde and to Sir Winston Churchill.

Implications for Communication

It has been noted that translators of scientific or technical texts are faced with special challenges since the terms do not represent only delimited concepts but also point at other implicit knowledge underlying the information in the text.[5] Consequently, finding correspondence between correlated terms in different languages is not sufficient to make a translation of CBRN texts. In analogy with this, an epidemiologist, a laboratory technician, or a police officer, when asked to perform a risk- or threat assessment, would rely on an implicit definition of the term but also on implicit knowledge of the protocol to be used to delimit the assigned task. Similarly, from one viewpoint, the terms *epizootic* and *contagious* refer to infectious disease spreading among animals and humans, respectively. However, in a disease control context, the terms also point at legislation that is well known by veterinarians and medical doctors but not necessarily by police officers and scientists. This suggests that even if it was possible to force joint terminology and definitions on international and national organizations, this would not be sufficient to ensure an unequivocal communication standard since the terms would still be associated with implicit knowledge.

It is well recognized, for example, in medicine, that a professional terminology or jargon can contribute to efficient communication in a group or profession while being a barrier to understanding for people outside the group.[26] It has been claimed that standardized terminology is utopian, since terminology is not static and term usage may reflect knowledge, professional status, and even power relations in groups of users.[5,48]

Disputes over terminology may take place when the use of a term to categorize an activity of one organization is interpreted as an intrusion into the domain of another organization. Examples of sensitive terms identified in the project are *threat assessment*, *evaluation of evidence,* and *risk management*, which refer to activities that according to some definitions should be done exclusively by the police, the court, and the risk manager, respectively, the latter being the "organization with authority to decide on the acceptability of risk levels."[49] In these situations, flexibility and cooperation are more important than definitions.

It is commonly stated that organizations should adopt joint definitions for common terms. However, it is important to be aware that this may be impossible or very difficult in cases in which the same lexical expression has been assigned term status in multiple contexts so that the same expression may refer to different concepts. A joint definition for such terms, including threat, biosecurity, and risk analysis, would be broad and would probably not reflect the usage of the terms in practice. For the purpose of supporting unequivocal communication, a consensus definition might be useless or even misleading unless it is accompanied by references to the domain-specific definition or explanation. This is because the devil is often in the details, and we have observed that miscommunication in the CBRN field may result from a failure to recognize that a word or expression is not used in its general sense but as a term in a specific context.

Experience from the cross-disciplinary activities in this project showed that unequivocal communication between languages and disciplines can be achieved only through awareness of the differences in terminologies and through mutual respect. When sending a message, it is important to recognize that the receiver may not use the same implicit ontology, and, similarly, when receiving a message, it is important to recognize that the intention of the sender may be different from what you assume, based on your implicit ontology. Consequently, the specialized terminology that is very efficient within a group or profession may not be appropriate in a cross-disciplinary context, since it relies too much on implicit assumptions and knowledge. Special attention should be paid to terms that, as in the examples above, point at specific national laws, EU directives, or instructions to authorities, and it may be good advice to indicate clearly in the definition or in a note applied to usage when a term is used in a legal context. However, paying appropriate respect to terms with a specific meaning in legislation is difficult without prior awareness, and machine reading tools, which scan a text for legal terms, may be helpful for preventing misinterpretations.

In addition, it is important to recognize that the choice of vocabulary/terminology may intentionally or unintentionally send signals that could either promote communication or result in conflicts and suspicion. The conclusion is that cross-disciplinary communication is not primarily about joint definitions but rather about developing social skills and learning to talk and write without relying on implicit knowledge. Needless to say, texts describing agreements, regulations, calls, and policies must not rely on implicit understanding of terms or the sense in which they are used. The first priority is to define the intention of authors, and when terms are used, it is essential to provide a definition that reflects this intention or to specify in which sense or according to which domain ontology it is used. The term *risk management* is a clear example; one should specify if this term is used in the sense of the CAC procedural manual or the laboratory biorisk management standard.

Tools for Supporting Communication

A lot of time and resources have been invested in the construction of glossaries and definition lists for CBRN, but since most are in text format, it is time consuming to find out if a particular term has alternative meanings or if there are better synonyms. Although initiatives have been undertaken to produce multilingual glossaries—in, for example, CBRN[24] and disaster risk management[50]—they are largely "mono-disciplinary," with each term (lexical expression) represented by a single entry. For example, the definitions related to analysis and management of risk only correspond to one of the alternative concept systems in Figure 2, and there is no mechanism to handle situations as in Table 2, where the appropriate translation is context dependent. In order to handle such challenges, it is necessary to represent terminologies as *conceptual glossaries,* in which the concept rather than the lexical expression forms the basis of an entry.[19] A structured representation of the terminologies from different organizations, constructed as domain ontologies, may be a valuable complement to existing glossaries and definition lists and would facilitate interdisciplinary comparisons. The large number of synonyms, acronyms, and related terms also can be a problem when text is read by computers—for example, in the search for scientific literature or when social media or other internet resources are scanned for signals of bioterrorism. For such applications, domain ontologies from different disciplines, including SNOMED,[18,46] could be valuable resources. Machine readable definitions also offer support for visual representation of the relations between concepts and may be more informative than a large number of independent written definitions.

A computer-based tool that connects glossaries or ontologies with a spell-checking or reference management system may help to make users aware of alternative concepts or systems and might encourage users to specify in which sense a term is used. An introduction to ontologies for risk management was produced in the WIN project.[10]

A structured query language (SQL) database, even in the simple form developed as part of this project, is superior to text files or spreadsheets for managing a term collection. An SQL database is used to retrieve and sort terms and can be used to address features like related terms, synonyms, acronyms, context, contributing organization, and source reference. However, it is clear that the manual construction of such a database, by copying or retyping terms and definitions from text lists, is laborious and may result in the introduction of errors. Furthermore, definitions change with time, and a static database rapidly becomes out of date unless each competent body or organization continuously updates its own terms and definitions. The problem with manual maintenance and updating a database over time will grow even larger if it contains structured terminologies and ontologies from multiple domains and languages. Not surprisingly, the experience of the health sector is that the building of extensive ontology tools is extremely demanding of resource. Large investments have already been made to promote semantic interoperability in the defense and health sectors. It is important that the existence of databases like SNOMED[18] and MGRM[50] and the experience from projects like IST-75[15] and Semantic Health[17] be considered before new terminology projects are initiated in the CBRN field.

Glossaries from various disciplines and organizations provide definitions that are valid in their domain, but in bioterrorism communication a major obstacle is to identify a suitable glossary for a particular task. In the short term, the most valuable contribution might be a searchable repository for glossaries and definition lists from different competent bodies like NATO, DHS, Interpol, Europol, EFSA, CAC, FAO, organizations like ISO and UIPAC, projects, standards, and scientific publications. A glossary of glossaries would be a useful tool for communicators, translators, and others working in a cross-disciplinary field and would be a valuable working tool for people and organizations developing and maintaining other official termbanks, ontologies, and the like.

Conclusions

The use of terms and definitions in CBRN activity, and the effect on the quality and integrity of multidisciplinary and multilanguage communication, is complex and relatively unstructured. As part of a multidisciplinary international CBRN project, AniBioThreat, we have (1) examined the incorporation of relevant terms and definitions in a prototype database, (2) consulted with terminology experts in relation to current usage, and (3) identified particular terminology issues associated with project partners and explored other projects that have addressed similar terminologies. This exploration leads to some conclusions in relation to improved awareness of existing issues and challenges for future development of consistent communication strategies for CBRN.

- In the short term, the resolution of terminology differences between languages and disciplines appears impractical and an initial focus on improved awareness of alternative definitions and ontologies, involving many stakeholder groups, may be superior to the provision of absolute or preferred definitions. This process places an emphasis on social skills of specialist communicators and on the use of common language rather than on the alignment of specialist sets of terms.
- An effective system supporting CBRN communication must integrate information on the *semantics* and *pragmatics* of the terms—that is, definitions of the concepts and information on how they are used in different contexts. Technological support for this process may follow similar developments to those in other fields and may

involve the development of a searchable scheme that integrates several existing structures.

- Existing glossaries and term banks relating to CBRN communications provide a large resource for the consideration of terminology, but currently their integration and annotation is weak. A process to establish representative corpora, suitable for machine-based analyses, may be an appropriate step forward.
- Legal terms, and terms that relate to specific national issues, present a particular problem for communications during multinational CBRN operations.

Acknowledgments

This research was supported by/executed in the framework of the EU project AniBioThreat (Grant Agreement: Home/2009/ISEC/AG/191) with financial support from the Prevention of and Fight against Crime Programme of the European Union, European Commission—Directorate General Home Affairs. This publication reflects the views only of the authors, and the European Commission cannot be held responsible for any use that may be made of the information contained therein.

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Manuscript received December 21, 2012;
accepted for publication June 7, 2013.

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