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Research article

Terminology as a strategic support tool in crisis situations such as the COVID-19 pandemic

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The COVID-19 pandemic has resulted in the introduction of numerous terms not fully understandable to ordinary citizens. Time pressure forced us to communicate about large numbers of new concepts, necessitating concept clarification. The aim of this article is to demonstrate the usefulness of the traditional terminological method and of terminological ontologies as strategic support tools in crisis situations. Terminological ontologies are advanced concept systems extended by subdivision criteria and characteristics. The article describes fundamental aspects of the traditional terminological method in respect of the interrelation between generic concept systems or terminological ontologies and definitions to ensure qualitative terminological results. Three types of definitions are suggested to meet the needs of the general public. Finally, arguments are provided for the claim that the traditional terminological method as such, in combination with concept systems and terminological ontologies in their capacity of visualisations, may act as strategic support tools. The illustrations are excerpts from a prototype of a Danish terminological ontology of 'testing' related to COVID-19.

Keywords: crisis communication, concept systems, terminological ontologies, definition types, visualisation

¹ Bodil Nistrup Madsen was mainly responsible for the ontology part.

La terminologie comme outil de soutien stratégique dans les situations de crise telles que la pandémie COVID-19

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La pandémie de COVID-19 a donné lieu à l'introduction de nombreux termes qui ne sont pas totalement compréhensibles pour les citoyens ordinaires. La pression du temps nous a obligés à communiquer sur un grand nombre de nouveaux concepts, d'où le besoin de tirer au clair lesdits concepts. L'objectif de cet article est de démontrer l'utilité de la méthode terminologique traditionnelle et des ontologies terminologiques en tant qu'outils de soutien stratégique dans les situations de crise. Les ontologies terminologiques sont des systèmes conceptuels avancés, étendus par l'utilisation de critères de subdivision et de caractères définitoires. L'article décrit les aspects fondamentaux de la méthode terminologique traditionnelle en ce qui concerne l'interrelation entre les systèmes de concepts génériques ou les ontologies terminologiques et les définitions, afin de garantir des résultats terminologiques de qualité. Trois types de définitions sont proposés pour répondre aux besoins du grand public. Enfin, des arguments sont avancés en faveur de l'affirmation selon laquelle la méthode terminologique traditionnelle en tant que telle, combinée à des systèmes conceptuels et à des ontologies terminologiques en tant que représentations visuelles des relations entre concepts, peut servir d'outil de soutien stratégique. Les illustrations sont des extraits d'un prototype d'ontologie terminologique danoise des tests COVID-19.

Mots-clés : communication de crise, systèmes de concepts, ontologies terminologiques, types de définitions, représentations visuelles

1 Background²

The early epicentre of the COVID-19 pandemic was the Huanan Seafood Wholesale Market in Wuhan where live animals were sold. In December 2019, the first cases of persons infected, with what turned out to be a novel coronavirus were confirmed and associated with this market. According to test results, it is likely that animals from the market spread the virus to humans (Worobey et al., 2022; Lundgren & Rasmussen, 2022, pp. 115-6, 123). On 11 March 2020, WHO assessed the COVID-19 as a pandemic (World Health Organization [WHO], 2020b). The coronavirus was designated SARS-CoV-2 and the resulting disease COVID-19 (Worobey et al., 2022), see Section 3.3 for more details. Three years later, the virus is still mutating and causing infections. And as of March 2023, over 758 million infections and over 6.8 million deaths were reported worldwide (WHO, n.d., update 1 March 2023). Globally, authorities introduced various behavioral restrictions to contain the virus. Restrictions included mask wearing, restrictions on public and private gathering, and travel restrictions (international and domestic).

Compared to other countries, Denmark has been rather successful in containing the COVID-19 pandemic. It was one of the first countries to lift its restrictions. However, in order to demonstrate the degree of uncertainty with which we were confronted in this pandemic, which was still ongoing when this paper was written, we shall start with a brief description of the progression of the disease in Denmark from the autumn of 2021 onwards (Sørensen & Nielsen, 2022a). By Mid-September 2021, Danish authorities no longer categorised COVID-19 as a “critical threat to society”; instead, it was categorised as a generally hazardous disease. Two months later, by mid-November, Danish authorities had to recategorise the disease as a “critical threat to society”. It was not until two and a half months later, at the end of January 2022, that the categorisation of COVID-19 as a “critical threat to society” ended, and restrictions were lifted. In other countries such as Germany and France, many restrictions were not lifted until March 2022, although at the same time the number of COVID-19 infected persons (e.g. in Germany, France, Great Britain, Italy, and Greece) continued to increase. This increase was caused by the Omicron variant. According to Jens Lundgren, a prominent Danish researcher in infectious diseases, the Omicron variant spreads more easily than earlier variants of the SARS-CoV-2 coronavirus causing COVID-19 (Lundgren & Rasmussen, pp. 332-333, 338, 341). By May 2022, test capacity was reduced. The antigen test centres were closed down, and PCR test capacity was reduced (Sørensen & Nielsen, 2022b). However, at the end of May, Mette Frederiksen, the Danish Prime Minister, announced that before the summer holidays, the Danish Government planned to present a strategy for handling future outbreaks of COVID-19 in the autumn (Ritzau, 2022; Lundgren & Rasmussen, 2022, p. 347).

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During the COVID-19 pandemic, in Denmark crisis management has been carried out by the Prime Minister, the Government, the Danish Health Authority, the Danish State Serum Institute, and the Police. The strategy planners have been challenged by many unknowns. Time and again, the Danish Prime Minister and the Health Ministry stressed the fact that restrictions and guidelines were based on the level of existing knowledge and thus subject to change as a result of the emergence of new knowledge and experience, if any. And, at frequent press briefings, daily updates, and interviews of health experts and politicians, many new terms were introduced which were not fully understandable to ordinary citizens or may not have been unambiguously defined by health authorities or politicians.

In addition to the occurrence of new concepts, a process of determinologisation took place, particularly involving terms originating from the domain of medicine and now observed in the general language. To quote an example, at one of the first national press briefings transmitted by the largest Danish TV stations, a representative of the health authorities mentioned the Danish expression for 'personal protective equipment' and continued "This includes such items as face mask,". Moreover, inconsistencies between Government announcements and those of health authorities resulted in continuous revisions of regulations and guidelines. A number of Danish terms related to the COVID-19 pandemic have been included in general dictionaries (Det Danske Sprog- og Litteraturselskab) and in subject-specific lists of terms with explanations by the health authorities (Statens Serum Institut [SSI]), but to our knowledge, no extensive systematic Danish terminology has been developed.

The terminological transformation experienced during the COVID-19 pandemic had three interesting characteristics. First, over a period shorter than ever experienced before, non-experts as well as experts (at varying levels of expertise) have been forced to learn and/or create new terminology in order to communicate about a large number of new concepts. Secondly, the new expressions affect populations nation- and worldwide, not only limited groups. And thirdly, individual countries have adopted different and changing strategies during the pandemic, resulting in the emergence of not fully compatible concepts and data. Obviously, this situation calls for clear definitions of pandemic terms, based on systematic terminology work.

The aim of this article is to demonstrate the usefulness of the terminological method and, in particular, of terminological ontologies as a strategic support tool in crisis situations, focusing on pandemics such as the COVID-19 pandemic. When referring to the terminological method as a strategic tool, we draw on the definition of 'strategy' found in the online Britannica Dictionary, the definition being "a careful plan or method for achieving a particular goal usually over a long period of time". The emphasis put on the characteristics of 'specific goal' and 'long period' is in accordance with most definitions in other dictionaries consulted.

The paper is organised as follows: Section 2 presents fundamental aspects of the terminological method concerning generic concept systems as the basis for creating qualitative terminological resources, and we describe the basic characteristics of terminological ontologies; in Section 3, we present the process of creating a prototype of a terminological ontology on the domain of ‘testing’ related to the COVID-19 disease, and the principles of the terminological ontologies are explained more in detail. In Section 4, we introduce different types of definition, taking into account the users’ various levels of knowledge on COVID-19-related concepts. Section 5 includes an example of terminological dynamics as well as differing strategies among countries. In Section 6, based on Sections 2 and 3, we present our arguments for the usefulness of the terminological method and, in particular, of terminological ontologies as a strategic support tool in crisis situations such as the COVID-19 pandemic; in addition, the importance of concept systems and terminological ontologies as visual representations is stressed. Finally, Section 7 comprises a number of concluding remarks. Figures in the article have been created using the terminology management system i-Term, see Section 2.2.

2 Terminological concept systems and terminological ontologies

Various articles on ‘terminological ontologies’ often refer to them using the terms ‘concept system’ and ‘terminological ontology’ as synonyms (Madsen, 2006, p. 271; Madsen, 2007, pp. 181, 187). However, for the purpose of this article, a distinction is required. Terminological ontologies may be defined as advanced terminological concept systems in that subdivision criteria and characteristic specifications are added. Before describing terminological ontologies in Section 2.2, we shall focus on essential aspects of terminological concept systems as the basis of ontologies. In this description, we shall address those aspects of the traditional terminological method that make concept systems and especially terminological ontologies suitable as a strategic support tool in crisis situations. This also implies the close relation between the two types of systems and definitions described in Section 4.

2.1 Terminological concept systems

The concept of ‘concept’ is defined as a “unit of knowledge created by a unique combination of *characteristics*” (ISO 1087, 2019, p. 3). However, concepts are not isolated units; they are always related to other concepts and thus form concept systems, as stressed by Suonuuti (2001, p. 14). Accordingly, a concept system consists of concepts and relations, which also appears from ISO 1087 (2019, p. 6), in which a concept system is defined as a “set of *concepts* structured [...] according to the *concept relations* [...] among them”. Add to this, Picht and Draskau (1985, p. 63) refer to the definition of concept system in the German standard DIN 2331, explicitly including the important perspective of a concept system as a coherent whole (“ein zusammenhängendes Ganzes”) (DIN 2331, 1980, p. 2). The Finnish terminologist Nuopponen summarises the relation between concepts and concept systems as concepts being the units that

constitute “the basis of knowledge”, whereas concept systems “organize this knowledge” (Nuopponen, 2018, p. 453).

The following description focuses on generic concept systems characterised by inheritance of characteristics from the superordinate concept to the subordinate concepts (ISO 704, 2022, p. 25). Characteristics make up the concepts and are used to describe them (ISO 704, 2022, p. 4; ISO 1087, 2019, p. 3). In terminology work, however, among many characteristics the focus is on the delimiting characteristics that are necessary to understand and identify a concept and distinguish it from related concepts (ISO 1087, 2019, p. 3; Suonuuti, 2001, p. 13). For instance, in the EU’s terminology data base, Interactive Terminology for Europe (IATE), ‘self-test’ is defined as “test intended by the manufacturer for use by lay users”; here, the characteristic ‘for use by lay users’ represents the delimiting characteristic. In generic concept systems, when dividing a superordinate concept into subordinate concepts, subdivision criteria such as PURPOSE, FUNCTION, METHOD may be added in the system in order to group the subordinate concepts according to an ordering characteristic. The visible inclusion of subdivision criteria supports the understanding of the concepts and provides insight into the coherent whole of the concept system (Suonuuti 2001, pp. 15-16; Madsen, 1999, p. 30; Picht & Draskau, 1985, p. 63).

2.2 Terminological ontologies

In what follows, we introduce the most central concepts related to terminological ontologies, and in Section 3.3 more details are presented.

The ontologies in Figures 1 and 3 refer to Danish concepts and their relations, shown in an English version, elaborated on the basis of English texts related to the COVID-19 pandemic. This means that no separate English ontology was created, but on the other hand the English terms are not just direct word-for-word translations.

Moreover, the figures in the article have been created using the terminology management system i-Term (DANTERM Technologies; Steurs, Wachter, & Malsche, 2014, pp. 239-242). i-Term consists of an internet-based term and knowledge base and a graphical module. In the graphical module of i-Term, it is possible to build traditional concept systems; however, the module has been specifically designed to handle terminological ontologies including the attribute-value pairs described below (Madsen, 2006, pp. 272).

Terminological ontologies are a further development of traditional terminology theory and may, as mentioned in Section 2, be defined as advanced concept systems. The basic characteristics of terminological ontologies are illustrated in Figure 1, which is an extract of Figure 3 below.

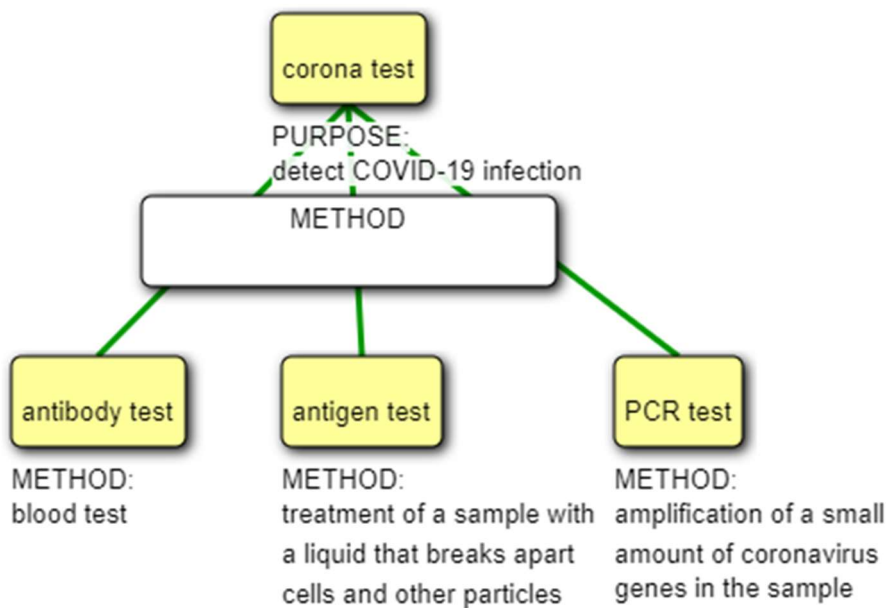


Figure 1. Example of an extract of a terminological ontology

The yellow boxes represent concepts with characteristics written below them. The green diagonal lines represent generic relations (type relations) between concepts, and the white boxes represent subdivision criteria. Moreover, terminological ontologies include attribute-value pairs representing the characteristics. This information is added below the concepts. For each concept within the same subdivision criterion, it is possible to identify a specific delimiting characteristic, i.e. value, in relation to the common subdivision criterion. For example, in Figure 1, ‘antibody test’, ‘antigen test’, and ‘PCR test’ all share the attribute METHOD, which is written in capital letters and inherited from the subdivision criterion METHOD. The values, i.e. the delimiting characteristics, are written in small letters, for ‘antibody test’ the value is ‘blood test’.

By using attribute-value pairs as the representation of characteristics, their relationship with subdivision criteria becomes apparent. The subdivision criterion corresponds to the attribute of the delimiting characteristic of concepts falling under that criterion (Christensen & Madsen, 2020, p. 469). Thus, unlike graphical representations of traditional concept systems, terminological ontologies visualise the way in which each single subordinate concept differs from the rest of the coordinate concepts under the same subdivision criterion.

3 The process of creating a prototype of a terminological ontology of ‘testing’ for Danish

In this section, we describe our terminological study of the domain of ‘testing’ related to the COVID-19 pandemic. We start out by describing the work process involved in the creation of the terminological ontology of ‘testing’. In addition to the description of terminological ontologies in Section 2.2, further principles and characteristics of terminological ontologies are presented in Section 3.3. They will be illustrated by the terminological ontology of ‘testing’.

3.1 Data

From the very start of the outbreak of the COVID-19 pandemic in 2020, the authors have extracted Danish terms related to the COVID-19 pandemic. The terms cover a broad spectrum of subject areas, not only those of health and medicine. The starting point of our analysis is texts describing the COVID-19 pandemic. Also, we included a term list by the Danish State Serum Institute (ISS, n.d. b). In order to verify terms and their meanings, we also consulted internet publications by the Danish health authorities. Moreover, we found a number of new words recorded in Den Danske Ordbog (the Danish Dictionary) (Det Danske Sprog- og Litteraturselskab, 2020).

In addition, we collected articles on COVID-19-related concepts from a national newspaper, focusing on articles including explanations of those concepts. This approach helped us extract terms and concepts immediately after their first occurrence, while they had not yet become an integral part of the vocabulary of the general public. In that period, with a group of students, we recorded relevant terms in the term base of i-Term. Here we applied a sort of brainstorming and manual term extracting approach. Of course, for further investigations, term extraction tools should be applied. Our first draft of ontologies of ‘testing’ and of ‘infection’ includes 75 concepts. So far, we have recorded a total of 161 concepts (209 terms) within eight domains.

3.2 Card sorting on COVID-19-related concepts

As a first step in our process of creating a terminological ontology of some COVID-19-related concepts, the terms identified were recorded in the term base of i-Term. As the next step, the authors conducted a so-called open card sorting using the graphical module of i-Term. Card sorting is a user-centered design method which is used by many information architects in information design processes in order to gain insight into the way people understand and classify information (Spencer, 2009, p. 6; Rosenfeld, Morville, & Arango, 2015, p. 344). In short, the process of card sorting involves giving groups of representative participants a set of cards with names or terms and asking them to organise those cards into logical groups. There are two basic types of card sorting: open card sorting and closed card sorting. In an open card sorting, the participants are given cards with items described on the cards, whereas the categories

are not pre-defined (Spencer, 2009, pp. 4, 52). Thus, the participants group their cards according to content and label their own categories (Spencer, 2009, p. 52). In a closed card sorting, the participants are provided with a set of pre-defined cards and categories and are asked to place content into the categories.

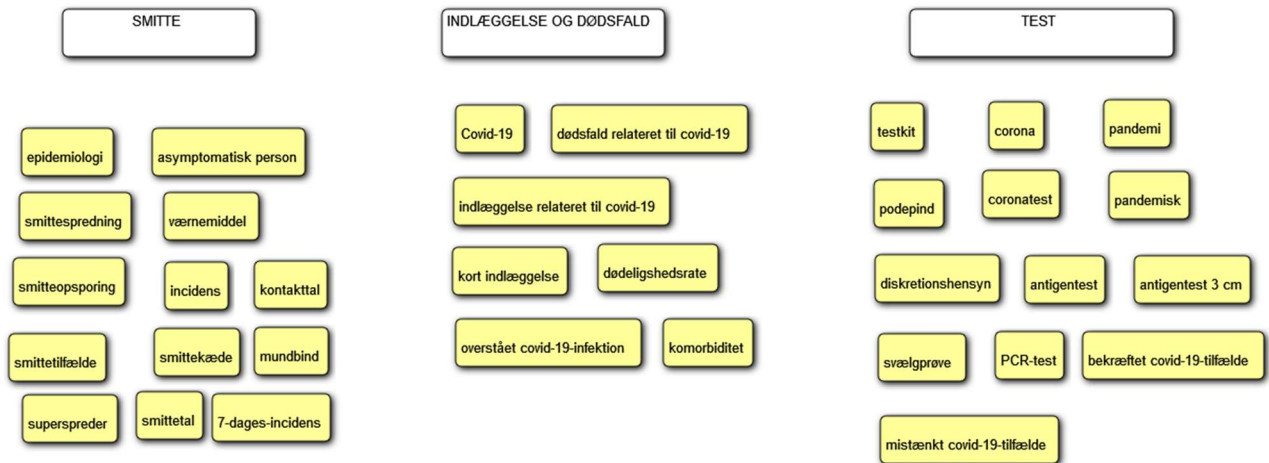


Figure 2. Open card sorting in Danish; extract of concepts: SMITTE (infection) – INDLÆGGELSE og DØDSFALD (hospitalisation and deaths), and TEST (testing)

Figure 2 shows an extract of our open card sorting on COVID-19-related concepts. The three white boxes represent categories identified, and the yellow boxes represent concepts. Applying card sorting helps in gaining a first overview of the concepts and their mutual relations. Normally, card sorting is conducted within a specific subject area, but our full card sorting differs from other card sorting processes, since the COVID-19 pandemic has influenced the terminology of various subject areas such as disease, health, economy, legislation, and culture. In order to simplify the illustration, Figure 2 only includes the categories directly related to the COVID-19 disease, i.e. SMITTE (infection), INDLÆGGELSE OG DØDSFALD (hospitalisation and death), and TEST (testing). This card sorting was taken as the starting point for the next stages of our ontology work.

3.3 Prototype of a terminological ontology of ‘testing’ for Danish

In this Section, in addition to the basic principles of terminological ontologies, introduced in Section 2.2, we add some more details on principles of terminological ontologies. Subsequently, a prototype of a terminological ontology of ‘testing’ for Danish is shown.

As mentioned in Section 2.2, terminological ontologies are a further development of traditional terminology theory and may be defined as advanced concept systems. The main principles on which terminological ontologies should be based were developed by researchers at Copenhagen Business School within the framework of the CAOS project

from 1998-2007. The aim of this project was to develop and validate ontologies semi-automatically (Madsen, Thomsen, & Vikner, 2004). This computer-aided approach implied the definition of a number of formal rules with which the structure of terminological ontologies should comply.

According to one of the formal rules (the principles), the values in the attribute-value pairs only include 'primary' characteristics, i.e. not inherited characteristics from the superordinate concept. Another rule prohibits overlap of subdivision criteria. Judging by the rules described here, it would appear that terminological ontologies containing attribute-value pairs were developed for generic relations (for more details, see e.g. Madsen et al., 2004; Madsen, 2007; Madsen & Thomsen, 2015).

The basic characteristics of terminological ontologies are illustrated in Figure 3, showing an extract of our prototype of an ontology of 'testing' for Danish. The full prototype of the ontology of 'testing' for Danish is shown in the Appendix. Moreover, we address the principles mentioned above.

Before explaining the ontology, a few facts about the COVID-19 pandemic are outlined. The ontology refers to SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). Unlike the first SARS-CoV, identified in 2003, it turned out that SARS-CoV-2 can be spread via pre-symptomatic as well as via asymptomatic transmission (Lundgren & Rasmussen, 2022, pp. 73, 135), both referring to transmission via persons who do not have symptoms. Pre-symptomatic transmission means that transmission may occur before a person develops symptoms. Asymptomatic transmission refers to transmission of the virus from a person who does not develop symptoms of the disease (WHO, 2020a). These characteristics corroborate the importance of testing and test capacity during the COVID-19 pandemic.

In his book "Vild virus" (Wild virus) released in 2022, Jens Lundgren summarises the evolution of SARS-CoV-2 stating that over the course of two years, we experienced four variants of the SARS-CoV-2 coronavirus, the first three causing increasingly severe disease following the appearance of each new variant, whereas much to the surprise of researchers, the Omicron variant was significantly less severe than previous variants of the virus (Lundgren & Rasmussen, 2022, p. 348). Omicron, first identified in late November 2021, is an immune escape variant of SARS-CoV-2 that is capable of easily breaking through the immunity obtained by vaccination. Thus, whereas Omicron is highly contagious, it has been proved to cause lower severity of disease (Lundgren & Rasmussen, 2022, pp. 325, 333).

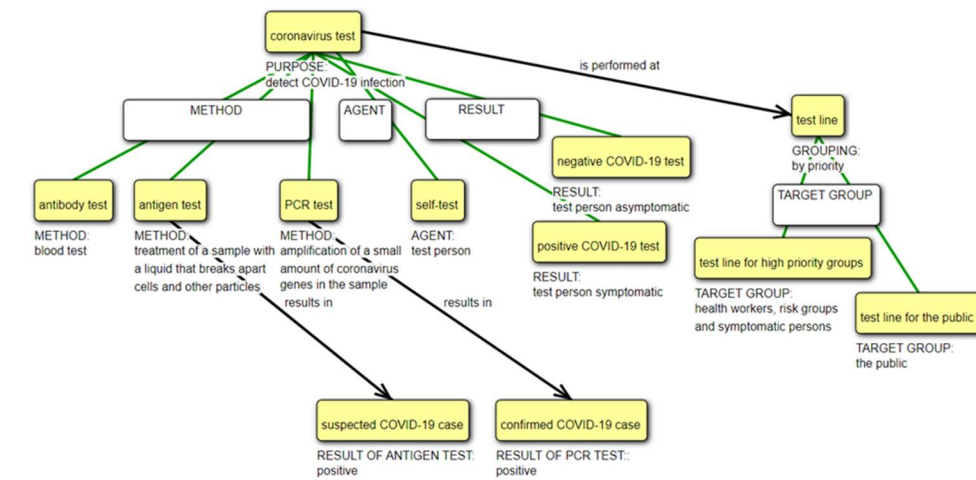


Figure 3. Extract of prototype of a terminological ontology of ‘testing’ for Danish (English version)

As described in Section 2.2, the yellow boxes represent concepts with characteristics added below them in the form of attribute-value pairs, e.g., for the concept ‘positive COVID-19 test’ the attribute-value pair is ‘RESULT: test person symptomatic’. The green diagonal lines represent generic relations (type relations) between concepts. The white boxes represent subdivision criteria, in this example ‘RESULT’. According to the formal rules, the attribute-value pairs only include ‘primary’ characteristics. This means that the attribute-value pair for ‘positive COVID-19-test’ does not include the attribute-value pair ‘RESULT: detect COVID-19 infection’ of the superordinate concept ‘coronavirus test’.

Whereas terminological concept systems were developed to support common understanding in human communication, terminological ontologies were developed with the specific aim of validating ontologies semi-automatically (Madsen 2007, p. 182). However, at the same time the terminological ontologies may turn out to be helpful to human users as well since they support consistency and provide a good overview of the specific concepts and their relations. For example, the formal description in the form of the attribute-value pairs helps the terminologist in ascertaining whether the subordinate concepts are mutually exclusive, preventing overlap, and it assists him or her in writing consistent definitions (Rosendahl, n.d., p. 5).

Even though terminological ontologies were originally developed for generic relations, they may also be applied for describing concepts in partitive and associative relations, though these relations are not characterised by inheritance of characteristics. Consequently, it is impossible to validate the specifications (attribute-value pairs) of these types of relations as the specifications are intended for generic relations (Madsen 2012, p. 17).

As an example, Figure 3 also includes associative relations. They are represented by the black lines with indication of direction and a label. For example the relation between 'PCR test' and 'confirmed COVID-19 case' is indicated by the label 'results in'. As appears from the full prototype of the ontology of 'testing' for Danish in the Appendix, quite a number of associative relations exist.

3.4 External aspects of the structure of concept systems and terminological ontologies

In the above description, we focused on the integral structure of generic concept systems and terminological ontologies. However, as stressed by e.g. Picht and Draskau (1985) and Nuopponen (2018), various external factors will also influence the structure of such systems during their elaboration. First, it is highly important to decide on the purpose as well as on the target group of the specific system (Picht & Draskau, 1985, pp. 64-65; Nuopponen, 2018, p. 454). Moreover, the systems should be flexible since this makes it possible to add concepts in the event of new concepts emerging. This precaution is especially relevant when dealing with rapidly changing subject areas such as pandemics, including the COVID-19 pandemic. After all, according to Nuopponen (2018, p. 454), concept systems are not static structures; they will change in accordance with changes in the real world and in knowledge. Our material clearly demonstrated this since early in the pandemic, the Danish Health Authorities recommended the Danish term 'kontakttal' to designate 'the effective reproductive number' instead of the term 'smittetryk' commonly used until then (SSI, n.d. a). (A direct word-to-word translation for 'kontakttal' would be '*contact number' and for 'smittetryk' '*infection pressure'). We will return to these external aspects in Section 4.1, as well as in Section 5.

4 Terminological definitions

Concept clarification based on concept systems or terminological ontologies combined with definitions is the backbone of all terminology work. This fact is also emphasised by Suonuuti (2001, p. 19), who points to the correlation between the quality of the overall terminology work and the quality of definitions. At the same time, and in accordance with ISO 704 (2022, p. 34), she addresses the close relation between definitions and concept systems with generic relations. She explicates the precondition for delineating definitions: as the first step, related concepts and the relations among these concepts in the specific concept system should be identified. Identifying the relations among the concepts will then facilitate the process of preparing brief and precise definitions that place concepts correctly in the concept systems and describe them correctly. Thus, concept systems and subdivision criteria assist the terminologist in writing consistent definitions (Suonuuti 2001, p. 19; Christensen & Madsen, 2020, p. 474).

The intensional definition, generally recommended for traditional terminology work, is characterised by a formal structure: it starts by introducing the term designating the immediate superordinate concept (the genus proximus), which is followed by the delimiting characteristic(s) (the differentia specifica) only (Suonuuti 2001, p. 20; ISO 704,

2022, p. 33; Picht & Draskau, 1985, pp. 49-52; Thomsen, 2017). This structure corroborates the close relation between concept systems and definitions as emphasised by Suonuuti (2001, p. 19).

4.1 A proposal for three types of definitions

In crisis situations such as the COVID-19 pandemic, non-experts and experts alike are affected and should have access to adequate, comprehensible information. In order to address this issue, in what follows, we present three types of definitions, i.e. general definitions, technical definitions, and explanatory definitions. The English part of the term article of the concept 'antigen test' is used to illustrate the three types of definitions, see Figure 4 below.

The term article of the term base of i-Term includes two predefined text fields for definitions, i.e. general and technical definitions. Traditional intensional definitions are placed in the field General definition. Technical definitions provide much more specific information. In the case of concepts related to the COVID-19 pandemic, the technical definition would typically be intended for health workers and authorities. This subdivision into general and technical definitions in i-Term was originally based on the experience collected from a project with the title *Development of Methods and Tools for the Creation and Operation of Corporate Term Bases*, normally referred to as the DANTERM centre contract. The three-year project was initiated by the Copenhagen Business School and the University of Southern Denmark and conducted in co-operation with six major Danish companies. The project became the first centre contract within the Humanities to be supported by Danish Research Council Foundation (DANTERMcentret 2001, p. 5; Steurs, Wachter, & Malsche, 2014, pp. 239-242). To supplement the two types of definition mentioned above, we propose a text field called Explanatory definition (contextual definition), which is written in informal language, and which provides the typical user (non-experts) with more information. The explanatory definition proposed is inspired by the so-called dissemination definition, including more information than intensional definitions, introduced by the Danish National Board of Social Services. The Board did this on the basis of their practical experience with definitions used in work situations (Rosendahl, n.d., p. 13; Socialstyrelsen, n.d.).

Our proposal for implementing explanatory definitions in i-Term is shown in Figure 4. In the field (data category) Explanatory definition, definitions in both English and Danish are given. The proposal is intended for testing whether users may benefit from this type of definitions, e.g. translators. Otherwise we may create two different fields in each language. Finally, a Comment field may be added, which contains supplementary information, e.g. on the strengths and drawbacks of testing methods. In Figure 4, we have left out the Comment field.

Subject:	Corona
Explanatory definition:	An antigen test involves collecting nose and throat secretions via nasopharyngeal swab and then examining them for protein fragments specific to the COVID-19 virus. While these tests provide quick results—within 15 minutes—they are generally considered to be less accurate than PCR tests. En antigenetest, der også bliver kaldt en lyntest, hvor man ved hjælp af en prøve fra næsehulens bagvæg påviser, om der er antigener (virusproteiner). Metoden er mindre følsom og præcis end PCR-testen, fordi antigenerne ikke opformeres, men påvises direkte.
Concept ID	16369793891845
English:	antigen test
General definition:	coronavirus test where a sample is treated with a liquid that breaks apart cells and other particles
Technical definition:	Antigens are substances that cause the body to produce an immune response – they trigger the generation of antibodies. These tests use lab-made antibodies to search for antigens from the SARS-CoV-2 virus. To run an antigen test, you first treat a sample with a liquid containing salt and soap that breaks apart cells and other particles. Then you apply this liquid to a test strip that has antibodies specific to SARS-CoV-2 painted on it in a thin line. Just like antibodies in your body, the ones on the test strip will bind to any antigen in the sample. If the antibodies bind to coronavirus antigens, a colored line appears on the test strip indicating the presence of SARS-CoV-2. https://theconversation.com/whats-the-difference-between-a-pcr-and-antigen-covid-19-test-a-molecular-biologist-explains-170917
Comment:	

Figure 4. The English part of the term article of the concept ‘antigen test’

4.2 Definition writing

If it is decided to include all three types of definitions in a term base, the writing of these definitions should not be seen in isolation. Intensional definitions may be considered an intermediary between more wordy explanatory definitions and attribute-value pairs. Thus, different approaches may be considered for writing definitions.

The objective of intensional definitions is to provide only the amount of information sufficient for identifying and delimiting the concept from other related concepts,

especially coordinate concepts (ISO 704, 2022, p. 33). This is the reason why only delimiting characteristics should be included in this type of definition.

Often, explanatory definitions include the term designating the superordinate concept and the delimiting characteristic, though without actually complying with the strict format of intensional definitions. Thus quite often it is possible to reformulate them to meet the formal requirements (Picht & Draskau 1985, pp. 54-55; Christensen and Madsen 2020, p. 474). In Christensen & Madsen (2020, p. 475) some examples within the subject area incident management are given.

Evidently, the structure of attribute-value pairs shown in the terminological ontologies is even more formalised than that of intensional definitions since the attribute-value pairs only consist of the subdivision criterion and the delimiting characteristic. Thus, attribute-value pairs and terminological ontologies provide a very good overview for easy identification of both the immediate superordinate concept and delimiting characteristic and may be utilised for writing the final intensional definitions, i.e. when a terminologist consults an expert for concept clarification (Madsen, 1999, pp. 76-77). In this way, ontologies provide the user with more information than traditional concept systems and may support consistency even more than traditional concept systems. However, since attribute-value pairs were designed for semi-automatic validation, the principles described in Section 3.3 will allow only one among a number of possible subdivision criteria of a subordinate concept (Madsen, 2007, p. 182). Thus, a drawback of utilising attribute-value pairs is that they do not permit the use of ambiguous characteristics called for in some cases. Therefore, in those cases the terminologist has to choose the most essential subdivision criterion including the delimiting characteristic for defining the concept in question (Madsen, 2007, p. 192). However, for concept clarification, Madsen proposes the creation of more than one version of an ontology. In descriptive terminology work, it might be relevant to suggest different ontologies, whereas in normative terminology work, the terminologist will have to decide on one subdivision criterion only (Madsen, 2007, p. 195).

Below in Table 1, the difference among the explanatory definition, the intensional definition, and attribute-value pair is exemplified by the concept of 'antibody test'.

Table 1. Different descriptions of the English concept 'antibody test'

Antibody test	
Explanatory definition	An antibody test can tell you if it's likely you've had COVID-19 before. It checks if your body has created antibodies to the virus or if these are from the vaccine.
Intensional definition	coronavirus test where a blood sample can check if the body of a person has created antibodies to the virus or if these are from the vaccine
Attribute-value pair	METHOD: blood test

It should be stressed that in cases where a definition is displayed together with a terminological ontology or a concept system, the user may deduce more characteristics from the system. Thus, if a definition occurs in isolation, i.e. without any context such as a concept system or a terminological ontology, the user may probably need more characteristics for understanding it (Picht & Draskau, 1985, p. 52). As mentioned in Section 4.1, the Danish National Board of Social Services has introduced a definition that also includes the characteristics of the superordinate concept, designated a dissemination definition (Rosendahl, n.d., p. 13; Socialstyrelsen, n.d.).

The choice of definition depends, among other things, on the target users, whether they are human beings (lay persons or experts) or computers. In general, explanatory definitions, being easier to understand, are suitable for lay persons, whereas experts may prefer intensional definitions and/or attribute-value pairs; finally, attribute-value pairs may also be used by experts and IT systems as a first step in data modelling (Christensen and Madsen, 2020, p. 474).

The graphical module of the i-Term interface may display attribute-value pairs from the graphical module as well as definitions recorded in the term base itself. This facility may support consistency control in general, just as it may assist the terminologist in creating consistent terminological ontologies and definitions.

5 Terminological dynamics and different strategies among countries

The pandemic has created huge communication challenges as to how to inform various target groups about new concepts, as well as how to explain the new concepts. Also, rapid changes in strategies arose during the pandemic as new knowledge was obtained, which in turn added to the complexity of this challenge. Complexity also increased because individual countries adopted different strategies, resulting in not fully compatible concepts as well as the lack of equivalents.

The Danish concept 'test line' ('testspor') and its subordinate concepts are used to illustrate the two challenges, i.e. terminological dynamics caused by changing strategies and lack of equivalence, see Figures 5, 6, and 7 below. The Danish concept 'test line' refers to the principle of how persons to be tested were selected. Thus, in this context 'test line' has nothing to do with the term 'test line' related to the Rapid Antigen Test kits. First, the concepts were short-term concepts, since this subdivision does not exist anymore. Secondly, we come across an example of equivalence differences among various language areas, since to our knowledge there are no English equivalents to the Danish concepts. Therefore, we have proposed English translations. Consequently, we may consider leaving out the concepts from the diagram, while keeping the terms and proposed translations in the term base only.

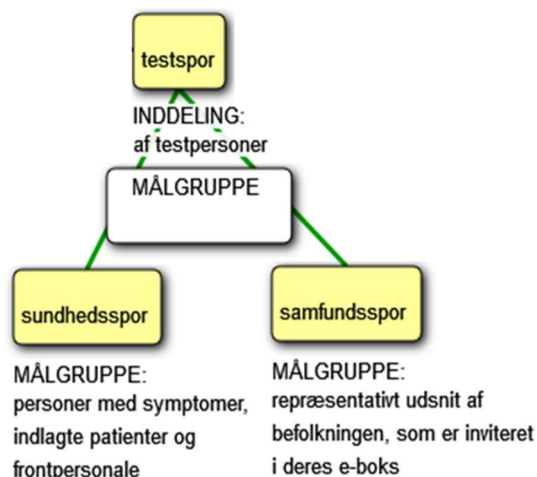


Figure 5. Terminological ontology of the Danish concept of 'test line' ('testspor')

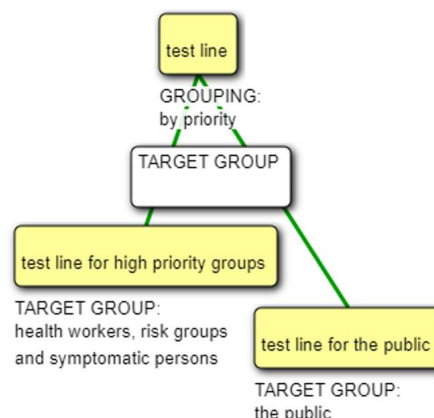


Figure 6. Terminological ontology of the English translation proposal of the Danish concept of 'test line' ('testspor')

In Figure 7 below, the English part of the term article of the Danish concept 'test line' ('testspor') from the knowledge base is shown. The term article includes Explanatory definitions in both English and Danish, followed by an English translation proposal. Finally, the Danish concept is explained in English, followed by a comment on the lack of equivalence.

Subject:	Corona
Explanatory definition:	The two test lines group test persons based on priority. De to testspor inddeler testpersoner efter prioritet.
Concept ID	16370670571379
English:	test line translation proposal
General definition:	line which organises test persons in two groups based on priority
Comment (equivalence):	The Danish concept 'testspor' and its subordinate concepts have no equivalents in English. Therefore, three translation proposals have been suggested.
Comment (editor):	We may consider to leave out the three English concepts in the diagram, and just keep the translations and definitions.

Figure 7. The English part of the term article of the Danish concept 'test line' ('testspor')

6 The terminological method as a strategic support tool

In what follows, we shall provide reasons for why the terminological method may be regarded as a strategic support tool to handle terminological dynamics of domains occurring in crisis situations such as the COVID-19 pandemic. First of all, we find it justifiable to consider the terminological method per se a very important strategic support tool. Consequently, we begin by arguing our position on that point. Next, we

shall focus on the role of concept systems and terminological ontologies as strategic support tools, in their capacity as visualisations.

6.1 The terminological method as a strategic support tool per se

As elaborated in Sections 2 and 4 concept clarification is based on the close interrelation between generic concept systems and definitions. Thus, conducting terminology work (keeping in mind this close interrelation) implies a degree of thoroughness and a foundation particularly suitable for supporting terminological preparedness in crisis situations, since it facilitates the structuring and organising of an abundance of information. In our opinion, this justifies our description of the terminological method as a strategic support tool per se. Compared to traditional generic concept systems, terminological ontologies provide a formalisation of traditional terminology principles. This formalisation strongly supports consistency in the ontologies as well as the writing of consistent definitions, since they are based on the attribute-value pairs (Madsen, 2006, p. 282). The importance of structuring and organising information in 'traditional' ontologies and taxonomies is also emphasised by Gaur et al. (2019) and Sihna and Dutta (2020), among others, in connection with crisis management concerning natural disasters such as floods and hurricanes.

Often, as a result of time pressure, concept systems have not been established in practical terminology work. However, the significance of generic concept systems or terminological ontologies as the foundation of terminology work as well as a basis for the writing of precise and clear definitions should not be underestimated. As stated by Suonuuti (2001, p. 21), unambiguous communication is based on unambiguous description of concepts.

Also, concept systems and terminological ontologies, forming part of terminological resources in general and of a domain such as the COVID-19 pandemic in particular, may function as important communication tools. During the drafting process of concept systems and terminological ontologies, they may assist terminologists and specialists in their efforts to clarify concepts (Nuopponen, 2018, p. 463). Later, the visualisation offered by concept systems and terminological ontologies may help end users better understand domain-specific terminology. As an example, for end users the Danish Data Health Authority (Sundhedsdatastyrelsen, n.d.) provides public access to their term base Begrebsbasen (the Concept Base), as well as to their concept systems, including direct access from a specific term article to the related terminological ontology (Sundhedsdatastyrelsen, n.d.).

6.2 The significance of visualisation

The importance of visualisation is also known from concept maps (Novak and Cañas, 2006). Many points of similarity exist between terminological concept systems and concept maps, although they have been developed independently of each other

(Nuopponen, 2016, p. 196). Concept maps are described as graphical tools for organising and representing knowledge. They have been used as a method of increasing meaningful learning by learners actively constructing knowledge as concept maps. For instance, before teaching a specific topic, teachers may ask their classes to construct a concept map on the topic in question in order to get knowledge about the learners' level of knowledge. Having covered the topic, the teachers may ask their classes to construct a new concept map on the same topic in order to study whether the attainment levels of the individual learners have improved. Concept systems and concept maps are both born with a hierarchical structure, with the most general concepts at the top of the structure. Moreover, like concept systems, concept maps include concepts and relationships between concepts. The relations are indicated by a connecting line linking two concepts. On the line, words, so-called linking phrases, specify the relationship between the concepts. This makes it possible to add associative relations. As illustrated in Figure 3 and in the Appendix, in terminology work it is also possible to add specific labels indicating the type of relation to the relations in the diagram. Thus, there is also a close relation between the two methods as far as associative relations are concerned (Novak and Cañas, 2008; Nuopponen, 2016). In continuation of concept maps and their visualisation, the satellite model developed by Anita Nuopponen (2016) in the 1980's should be mentioned. The satellite model resembles mind maps and concept maps, but the model was developed independently from them and combines terminological methods and visualisation (Nuopponen, 2016, p. 190). Traditional concept systems including generic and partitive relations are mostly visualised as tree diagrams. Nuopponen wanted to develop a more flexible method for integrating associative relations, which was not easy using traditional concept systems. As the name indicates, the model imitates a satellite system with a central concept around which satellites nodes are placed, representing related concepts. The method permits the addition of new concepts in a more flexible way than that of tree diagrams (Nuopponen, 1998, p. 365; Nuopponen, 2016, p. 194). Each satellite may have its own satellites, and satellite nodes may contain concepts or represent any type of relation. Nuopponen stresses the importance of graphical representations for common understanding and concise communication (Nuopponen 2016, pp. 190, 196).

Albeit in another context, in their research on transforming text summaries into text visualisation, Chongtay et al. (2013) argue that text transformation into a visual representation makes the text more concrete and understandable to learners. Also, they refer to other studies showing that people learn better with the combination of words and pictures than with each of them alone (Mayer 2021, p. 135). In the field of terminology, Lervad, Flemestad, and Weilgaard (2016) include a wide range of combinations of words and pictures in addition to concept systems and terminological ontologies, relating to verbal and nonverbal representation in terminology.

However, that being said, a study by Nielsen (2016) including a dual visualisation comprising a terminological ontology and a corresponding textual term article resulted in certain reservations being brought forward. In the study, the domain of 'taxation' was

explored, and the test persons were professionals within taxation. Participants were asked to search for information in a dual visualisation. During the experiment, eye-tracking technology was integrated. As a general result, more time was needed for answering questions referring to diagrams (terminological ontologies) only, compared to answering questions related to texts only, or to a combination of diagrams and articles. However, in the study it is concluded that the results indicate that the visualisation of concepts by means of terminological ontologies ought to be an integral part of terminological resources, since in this way users are able to acquire knowledge based on ontologies, despite relatively long reasoning times (Nielsen, 2016, p. 231).

7 Concluding remarks

During the COVID-19 pandemic, citizens were confronted with a lot of unfamiliar terms and concepts. Often, understanding these terms and concepts in order to comply with the regulations stipulated by the authorities was critical. As was mentioned in Section 1, in Denmark, explanations and definitions of COVID-19 key terms and concepts were published in various documentation on the website of the Danish health authorities. However, for future pandemics at the national level, for authorities a term and knowledge bank may serve as a common platform and an efficient tool for giving all users access to the same structured information in the form of definitions and terminological ontologies. This may support common understanding of key concepts and ensure efficient communication. We recommend that such a future term bank integrate visualisations in the form of concept systems or terminological ontologies and definitions at different knowledge levels.

Traditional concept systems aim at concept clarification and common understanding among professionals in specific subject areas, i.e. they have humans as their target group. The idea behind introducing terminological ontologies has been to add formalised descriptions of characteristics in the form of the attribute-value pairs, suitable not only for humans, but also for IT systems, since they may form a first basis for data modelling and thus for developing IT systems (Madsen & Thomsen, 2015). In the Danish public sector, e.g. in the term base of the Danish Health Data Authority, terminological ontologies have already been implemented as a basis for IT development. At the same time, the attribute-value pairs of terminological ontologies imply first drafts of text definitions and help identify the immediate superordinate concept. Moreover, the attribute-value pairs include the delimiting characteristic to be used when writing intensional definitions (Thomsen 2017).

The need for communication at various levels has been extraordinary during the COVID-19 pandemic. In order to meet this challenge, we propose different types of definitions. Specialists or terminologists have the possibility to record definitions at different levels while still describing concepts consistently. Thus, applying the terminological method makes it possible to meet the requirements of different target groups since it allows individual users to select a definition corresponding to their level of knowledge and their

purpose in searching for information. The user group may include ordinary citizens, translators, documentalists, journalists, and specialists. In our study, we found examples in newspaper articles, in which COVID-19 key terms were explained very briefly and/or inconsistently. For journalists, a term and knowledge bank could serve as an important and valuable reference.

In our study, we have focused on monolingual terminological ontologies of COVID-19-related concepts in Danish. To be able to share knowledge worldwide, individual national ontologies of pandemic concepts are a first prerequisite for comparing different and changing strategies of the COVID-19 pandemic and for future pandemics at a global level. In order to conduct such studies, we consider visualisations in the form of concept systems and terminological ontologies illustrating concept relations to be important strategic support tools.

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