"What exactly is a lockdown?": Towards an Ontology-based modeling of lockdown interventions during the COVID-19 pandemic

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***Abstract.** The COVID-19 pandemic posed several research opportunities raised by the huge amount of data collected and made available at an unprecedented rate. However, this also raised important challenges for manipulating all this data and extracting knowledge from it, due to the lack of semantically precise definitions. In particular, several locations imposed lockdown measures for some periods, with different meanings among them. These semantic differences might help to explain why different countries - which at first sight enforced similar sets of interventions - evolved in a completely distinct way with respect to the propagation rate of COVID-19. In this work, we report an ontological analysis of some lockdown interventions. These interventions are classified in the same category in a taxonomy provided by a worldwide initiative that tracks information on interventions from governments of several countries taken to tackle COVID-19. However, as our analysis shows, there are important ontological distinctions among them. Based on these results, we propose an initial version of a domain ontology that represents lockdown as a complex non-pharmaceutical intervention type, which is composed of interventions of several natures, and that provides a legal perspective of some of its composing interventions using patterns from the UFO-L legal core ontology.*

1. Introduction

The COVID-19 pandemic scenario motivated a series of worldwide collaborative efforts to understand the disease, control its propagation and mitigate its consequences. In this direction, several initiatives worked on collecting and sharing large amounts of data [WHO 2020] [Roser et al. 2020] and extracting patterns through the application of Data Science and Analytics techniques to better understand and fight the pandemic [Hussain et al. 2020] [Jamshidi et al. 2020] [Abdel-Basset et al. 2020] [Hu et al. 2020] [Li et al. 2020].

As the virus spread, several governments enforced different interventions (both pharmaceutical and non-pharmaceutical) for containing the pandemic [Davies et al. 2020] [Prem et al. 2020]. However, it is difficult to compare and evaluate the efficacy of these interventions between regions and countries because there are semantic distinctions in their definitions, and even seemly straightforward metrics reporting what can appear at first to be natural events (e.g., deaths per country) can hide subtle differences in meaning[1]. Also, several locations imposed measures that they dub "lockdown" for some period. However, as we show here, these measures have different semantics and implications. In fact, it is notorious that different countries, which allegedly enforced similar sets of interventions, evolved in a completely distinct way with respect to the propagation of the disease. This maybe due to several reasons, such as: (i) how they were formally formulated and legally enforced; (ii) the value and risk perceived by the population to adhere to governmental recommendations; or (iii) how citizens trust the institutions posing these recommendations. In the present work, we focus on the first reason.

Thus, in order to properly analyze and compare the effectiveness of these interventions among different countries, a consensual and shared model of the domain that explicitly takes real-world semantics into account (i.e., a well-founded domain ontology) is needed. Moreover, since these interventions define legal relations between geopolitical entities and their citizens, we claim that this model should explicitly account for legal relational properties - such as power and social subjection, freedom and social permission.

In this work, we focus on a particular type of non-pharmaceutical intervention (NPI), namely *lockdown*. We conduct an ontological analysis to understand the nature of lockdown interventions adopted in distinct places to control the propagation of the COVID-19 disease during the pandemic, and propose the first version of a domain ontology, grounded on the legal core ontology UFO-L [Griffo 2018, Griffo, C. et al. 2019][2]. Since UFO-L is based on the foundational ontology UFO [Guizzardi, G. 2015], we employ the UFO-based modeling language OntoUML [Guizzardi 2005b] to instantiate UFO-L patterns reused as building blocks in our domain ontology.

We claim that this ontology contributes to shed light on possible characteristics which make individual lockdown interventions distinct from one another. As a basis for our ontological analysis, we draw on the lockdown definitions as provided by a research project conducted by the Complexity Science Hub in Vienna[3] [Desvars-Larrive, A. et al. 2020]. This allows us to explicit ontological distinctions between different lockdown measures that are classified by this project in the same category, thus evidencing the semantic overload of their definitions in different lockdown occurrences.

The remainder of this paper is organized as follows: Section 2 discusses the concept of non-pharmaceutical interventions. Section 3 partially describes the UFO-L core ontology for the purposes of this work. Section 4 proposes a well-founded conceptual

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[1]https://analysis.covid19healthsystem.org/index.php/2020/06/04/how-comparable-is-covid-19-mortality-across-countries/

[2]A Legal Core Ontology is a kind of legal ontology that represents a shared conceptualization of generic legal concepts, which can be used and reused in the construction of other more specific legal ontologies.

[3]https://covid19-interventions.com/

model to represent the notion of a lockdown. Finally, Section 5 concludes this work and points to some future research directions.

2. Non-Pharmaceutical Interventions (NPI)

Non-pharmaceutical interventions (NPI) are containment measures, different from vaccines and medication, which intend to prevent or slow down the spread of a disease [CDC 2020]. NPIs comprise public health (such as the usage of facial masks) and social (such as travel restrictions) measures, and are branded as a community mitigation strategy. Because the pandemic virus is new, it potentially spreads quickly from one person to another and then to the entire world. Thus, NPIs are among the best ways to control a pandemic, specially when vaccines are not yet available [Haug, N. et al. 2020]. Moreover, even when vaccines are available, combining them with NPIs prevent the emergence of new variants of the virus, also contributing to control the pandemic.

The main goals of all countries is for the pandemic to be controlled by slowing the transmission of contagion and, ultimately, reducing the mortality caused by the virus. Even with common goals, the ways in which the NPIs are being applied vary according to the country, as evidenced by several initiatives that track and share information on interventions that governments have taken to tackle COVID-19, such as the Oxford COVID-19 Government Response Tracker (OxCGRT) [Hale, T. et al. 2021] and the CCCSL dataset from the Complexity Science Hub Vienna [Desvars-Larrive, A. et al. 2020].

The Oxford COVID-19 Government Response Tracker (OxCGRT) [Hale, T. et al. 2021] collects systematic information on policy measures taken since January 1st, 2020 on more than 180 countries. The collected interventions are coded into 23 indicators, such as school closures, travel restrictions, among others. These policies are recorded on a scale to reflect the extent of government action, and scores are aggregated into a suite of policy indices. The characterization of each measure accounts for its coverage in a very simple way, differentiating between total or partial closures, isolated measures or throughout the territory, and testing policies in people who have symptoms or in the entire population. In particular, no specific measure (or set of measures) is referred to as a "lockdown" by this project. Instead, the concept of a lockdown is mentioned as a generic characteristic of closure policies ("lockdown policies") that are considered to calculate the *stringency index*. The notion of stringency index, as defined by the authors, is reduced to a numeric value (calculated for each day and each country, from the set of active measures on that date and place). Therefore, there is no explicit definition for the concept of lockdown provided by this project.

The CSH COVID-19 Control Strategies List (CCCSL) [Desvars-Larrive, A. et al. 2020] is a project that collects, categorizes and shares a structured dataset of non-pharmaceutical interventions taken since March 2020 by the governments of 57 countries, in order to assess the impact of these actions on the spread of the COVID-19 in the respective countries. Measures implemented at the subnational level (state, region, city) are also included. The provided dataset describes the respective time schedules of the implementation of each NPI, and the sources of each intervention included in the catalog. NPIs are listed in a standardized manner, i.e. classified using the CCCSL taxonomy proposed by the authors, which is composed of four specialization levels: a *Theme* (L1 level) is a generalization of a *Category* (L2 level), which in turn is a

generalization of a *Subcategory* (L3 level), which finally generalizes a *Code* (L4 level). Eight major Themes were identified in the CCCSL taxonomy to categorize NPIs: (i) case identification, contact tracing and related measures; (ii) environmental measures; (iii) healthcare and public health capacity; (iv) resource allocation; (v) returning to normal life; (vi) risk communication; (vii) social distancing; and (vii) travel restriction. In this work, we focus on interventions of the two last themes, namely *social distancing* and *travel restriction*. According to the CCCSL taxonomy, a lockdown (actually named as "National Lockdown") is a NPI Category (L2-level) specializing from "travel restriction", meaning that, essentially, the CCCSL project defines a lockdown as being essentially a travel restriction measure. Moreover, its subcategories (L3-level) refer to distinct (and complementary) specialization criteria, including its duration ("For 2 weeks", "For 21 days", "For 4 weeks"), its coverage ("Partial Lockdown") and its enforcement level ("Safer-at-home Order", "Stay-at-home Order"). Figure 1 illustrates an excerpt of the CCCSL taxonomy focusing on two subcategories of interventions that are germane to the purposes of this article.
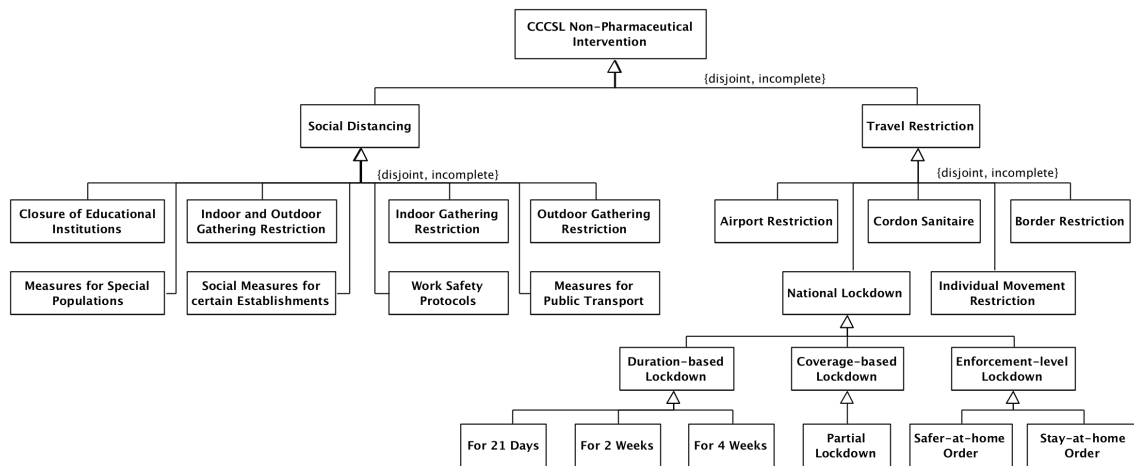
Figure 1. Graphical representation of the CCCSL NPI Taxonomy

2.1. The social versus legal dimensions of NPIs

Regarding aspects that mostly impact the expected effectiveness of NPI in different social contexts, we argue that the effectiveness of an intervention depends on the social *versus* legal dimension of the imposed restrictions. In the first weeks of the COVID-19 epidemic, some countries, such as Italy, established contention measures as mere recommendations or advice. Italy, for instance, recommended the wearing of masks only in cases of suspicious of infection[4]. However, with the worsening of the contamination scenario in Italy, the interventions that were previously given as recommendations became sanctioning prescriptions with the purpose of protecting the public health. For instance, the wearing of

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[4]"Misure igienico-sanitarie: (...) m) usare la mascherina solo se si sospetta di essere malati o se si presta assistenza a persone malate". DPCM dell' 8 marzo 2020 at www.gazzettaufficiale.it/eli/id/2020/03/08/20A01522/sg. Accessed: 03 Jul.2021.

masks became mandatory in Italy with the Decree-law of 26th April, 2020[5].

Thus, at first, the contention measures were frequently stated as social norms, i.e., present as recommendations in the social context without punitive consequences for those that do not observe them. A parallel can be made with ISO standards, which are guidelines based on good practices without however having the power of coercion. This coercion power can be added to this type of social norms when these norms are included in some legal object, for example, contracts or laws (in a narrow sense). When this occurs, norms overflow the social context (social dimension) and reach the legal context (legal dimension).

In the legal dimension, social relations receive a normative burden, which transform social relations in legal relations. It occurs because of the existence of an original relationship of power and subjection between State and citizens, which empowers the State to order the citizens' life. In this way, a legal relation is defined as a social relation between two or more social agents, which has been turn into legal norms by an entity legally empowered to do that (rules and principles). In the case of control measures, the legitimated entity is the State. Since the State has the power to regulate the conduct of all individuals in a given society, it also has the power to impose sanctions on those who fail to observe the prescribed conduct.

3. The core UFO-L Ontology and its associated patterns

UFO-L is a legal core-ontology that defines a *legal relation*, mentioned in the previous Section, as its key notion. UFO-L is grounded on UFO and based on the theory of constitutional rights proposed by the legal philosopher Robert Alexy [Alexy 2010]. This theory takes a relational stance on the law, in contrast with legal theories based on deontic logic that represent legal relations through monadic expressions (e.g., something expressed by a proposition P is overall obligatory, permitted, or forbidden). As a consequence of this view, a *legal relation* is defined as a bond between agents who stand in legal positions[6] playing particular *legal roles*. Legal roles are specializations of social roles, which are defined, prescribed, and assigned to agents or group of agents by means of legal norms (rules and principles). For instance, in a buyer-seller relationship, legally empowered agents play the roles of buyer and seller to produce a social phenomena relevant to law, namely, a legal economic transaction (*e.g., the buying and selling of a house*).

Legal relations follow certain patterns. In fact, UFO-L recurrently relies on two basic patterns in UFO/OntoUML, namely, *relator pattern* and *mode pattern* [Zambon and Guizzardi 2017]. A *Mode*, in particular a *Relational Mode*, is a property that inheres in one entity termed its *bearer* (hence, being *existentially dependent* on that entity), but which also depends on another entity external to its bearer [Fonseca, C. et al. 2019]. For example, If John loves Mary, his love (an entity by itself, which can have its own properties, can change in time) can only exist by inhering in John

- it is, after all, a concrete property of John's. However, it is also dependent on something external do John, namely, Mary. Legal properties such as duties, rights, subjects and powers (towards other agents) are examples of relational modes. A *Relator*, in turn, is a bundle of Relational Modes [Guarino and Guizzardi 2015, Fonseca, C. et al. 2019]. Examples include Paul & Linda's Marriage (composed of, e.g., their mutual rights and duties towards each other), Barack Obama's presidential mandate, Cristine's employment at UNIBZ, and Ingrid's enrollment at PUC-Rio. Relators are created by particular foundational events [Guizzardi 2005b] (e.g., weddings, enrolling acts, hirings, purchases). Furthermore, as discussed in depth in [Fonseca, C. et al. 2019], relators are the truthmakers of domain relations, i.e., the proposition "John and Mary are married" is true insofar as there is a relator of the type Marriage binding the two. Analogously, the proposition "Ingrid is a student a PUC-RIO" is made true by the existence of a particular Enrollment binding her and PUC-RIO. Social and *Legal Relators* are created by Normative Descriptions [Guizzardi, G. et al. 2008], which are accepted by certain collective agents (e.g., societies). They are them the truthmakers of Social and *Legal Relations* and inducers of Social and *Legal Roles*. The modes in a legal relator that inheres in one of the participating entities (called a *Legal Agent*) is called a *Legal Position*.

Relator types induce certain *roles* [Guizzardi 2005a], e.g., because they are bound by a relator of the type *Marriage*, Paul and Linda instantiate the role of *Spouse* (thus, bearing specific relational modes associated with that role, i.e., the mutual legal properties entailed by a Marriage); because she is bound to UNIBZ by a relator of type *Employment* in a certain way, Cristine instantiates the role *Employee* with its associated rights and duties, etc. *Mutatis Mutandis*, the same applies to UNIBZ playing the role of *Employer*. When a role-like type (e.g., Customer) can be instantiated by entities of multiple *kinds* (e.g., people, organizations), this is called a *Role Mixin*. Roles and Roles Mixins are dynamic type, i.e., individuals can move in and out of the extension of those types. In contrast, a Kind is a static type, defining properties that are essential and, hence, modally constant for their instances. Types that statically classify entities of multiple kinds are called *Categories*. For a full formal presentation of UFO/OntoUML, refer to [Guizzardi 2005b].

Finally, there is an intimate relation between *events* and modes (hence also between events and the relators constituted by these modes) [Guizzardi, G. 2016]. For example, the marriage between Paul & Linda as a complex event (a process) is the sum of the intentional events (acts) they perform playing the role of Spouse, i.e., manifestations of the particular modes inhering in them. Likewise, it is because of a given legal mode inhering in him (a legal power) that the (one playing the role of) President can create new legal norms, i.e. the event of creating a norm is a manifestation of that (power) mode.

A catalog of types of legal patterns based on UFO is proposed in [Griffo 2018]. These patterns were applied in different contexts, such as relations in healthcare compliance [Griffo and Castello 2021], in contracts of logistic sea corridors [El Ghosh and Abdulrab 2021], in decisions of juridical cases [Griffo et al. 2020]. In this paper, we focus on the Right-Duty to an Action and the Right-Duty to an Omission legal relation patterns. They are discussed in the sequel and represented using OntoUML. Besides the reusable OntoUML model snippets, for each pattern we present its rationale, guidelines for its use, constraints over the elements of its model, and a set of criteria that justifies its application.

3.1. *Right-Duty to an Action* Pattern (Code: P1-RDA-LR)

A Right-Duty to an Action is established between a Right Holder and a Duty Holder. The Legal Relator is formed by a pair of legal positions: a Right to an Action, inherent in the Right Holder and externally dependent on the Duty Holder; and a Duty to Act, inherent in the Duty Holder and externally dependent on the Right Holder. Like any legal relation, a Right-Duty to an Action is created, modified, or extinguished by an event (natural or social) relevant to the Law.
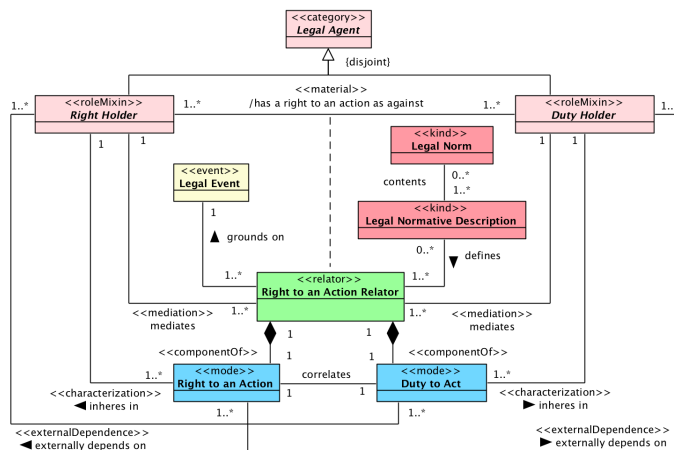

Figure 2. The Right-Duty to an Action Pattern. Source: [Griffo 2018]

The P1-RDA-LR pattern (Figure 2) must be used in legal relations that define conducts (positive compulsory conducts). The action must be a required conduct of the bearer of the position in correlation to the Right to an Action. In ontologies belonging to a legal field, the categories of legal roles (Legal RoleMixins) must be specialized in Legal Roles (so that each of these specializing roles can be associated with the suitable *kinds* of the entities that can play those roles). P1-RDA-LR enforces the following constraints: (A4) To every material relation "has a right to an action against", there is a conversing relation "has a duty to act towards"; (A5) A Right-Duty to an Action Relator is a relator made out of a Right to an Action and a Duty to Act inseparable from the legal relator and essential to it. The set of criteria for the application of the P1-RDA-LR pattern are the following: (i) Do the legal positions of the domain to be represented refer to rules of conduct?; (ii) Does the action, object of the legal relation, is a requirement of the category of the correlative position bearer?; (iii) Is the required action a positive action, that is, the requirement of doing something?; (iv) Are the Duty Holder and Right Holder roles clearly identified?

3.2. *Right-Duty to an Omission* Pattern (Code: P2-RDO-LR)

A Right-Duty to an Omission Legal Relator pattern is established between a Right Holder and a Duty Holder. The Legal Relator consists of a pair of legal positions: a Right to an Omission, inherent to the Right Holder and externally dependent on the Duty Holder; and a Duty to Omit, inherent to the Duty Holder and externally dependent on the Right Holder. Like any legal relation, a Right-Duty to an Omission is created, modified or extinguished by an event (natural or social) relevant to the Law. This event is the *foundation* of the Legal Relator. P2-RDO-LR (Figure 3) must be used in legal relations defined in conduct

rules (it regulates negative compulsory conducts). The omission (negative action), object of the legal relation, must be a required conduct from the Duty Holder. In legal ontologies the categories of legal roles (Legal RoleMixins) must be specialized into Legal Roles. This pattern enforces the following constraints: (A6) To every material relation "has a right to an omission against", there is a conversing relation relation "has a duty to omit towards"; (A7) A Right-Duty to an Omission Relator is a relator formed by a Right to an Omission and a Duty to Omit inseparable from the legal relator and essential to it. The first, third and fourth criteria of P1-RDA-LR also apply to this pattern.
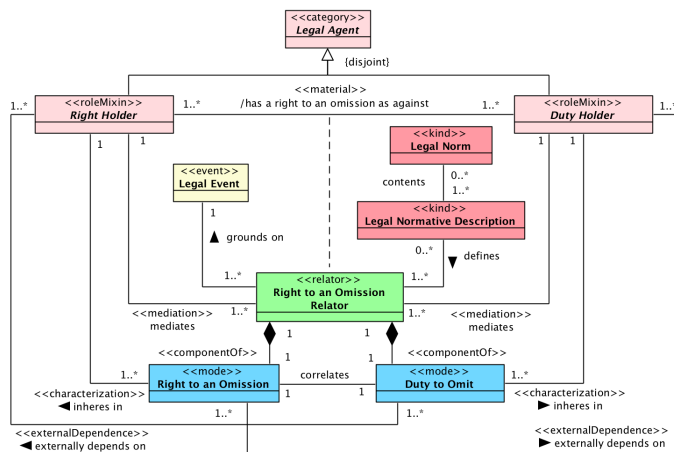

Figure 3. The Right-Duty to an Omission Pattern. Source: [Griffo 2018]

4. Modeling COVID-19 Lockdown Interventions

In this section, we employ the patterns presented in the previous section to conduct an ontological analysis of lockdown interventions adopted in distinct places to control the propagation of the COVID-19 disease during the pandemic. This analysis is based on the NPI data provided by the CCCSL dataset [Desvars-Larrive, A. et al. 2020]. Our analysis allows us to characterize the concept of lockdown and represent their various components. As a result, we are able to propose a new well-founded conceptual model in OntoUML, redesigned from the taxonomy for NPIs (of which lockdown is a significant representative).

In the CCCSL dataset [Desvars-Larrive, A. et al. 2020] there are 60 occurrences of National Lockdowns (L2 measures) distributed among 35 countries. An ontological analysis of some of these tuples evidences some problems with the current CCCSL taxonomy. Consider the following two instances of NPI in the CCCSL dataset:

France. The French authorities imposed a national lockdown on October 30th, 2020 by the means of the decree No. 2020-1310[7]. This intervention is described in the CCCSL dataset as follows[8]: *"Mr. Macron said that under the new measures, starting on Friday, people would only be allowed to leave home for essential work or medical reasons. Non-essential businesses, such as restaurants and bars, will close, but schools and factories will remain open. Covid daily deaths in France are at the highest level since April. On*

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[7]https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000042475143

[8]https://www.bbc.com/news/world-europe-54716993

Tuesday, 33,000 new cases were confirmed. Mr Macron said the country risked being 'overwhelmed by a second wave that no doubt will be harder than the first'. Meanwhile, Germany will impose an emergency lockdown that is less severe but includes the closure of restaurants, gyms and theatres [...] The president said that under the new rules, people would need to fill in a form to justify leaving their homes, as was required in the initial lockdown in March. Social gatherings are banned. 'Like in the spring, you will be able to leave your house only to work, for a medical appointment, to provide assistance to a relative, to shop for essential goods or to go for a walk near your house,' Mr Macron said."

Germany. The national lockdown in Germany occurred on Nov 2nd, 2020, and was also categorized as a L2-level National Lockdown in the CCCSL taxonomy. This individual lockdown is described in the CCCSL dataset as follows[9]: *"Germany in partial lockdown - new corona restrictions in force. Public life is again restricted. Restaurants, pubs and cultural institutions have to close, and citizens should limit their private contacts."*

As exemplified in the above descriptions, the NPIs that compose a specific lockdown measure vary from one country/region to another, resulting in different compositions that are not adequately considered in the original taxonomy (Figure 1). Tables 1 and 2 show the NPIs that compose the aforementioned lockdown examples, and detail the corresponding UFO-L patterns and Legal Agents used to model them.

Figures 4[10] and 5 provide novel conceptual representations of two interventions composing the french lockdown measures, as ontology excerpts. In particular, Figure 4 represents the closure of sites (non-essential businesses such as restaurants and bars) and Figure 5 represents the stay-at-home during the French lockdown, both using the Right-Duty to an Omission UFO-L pattern presented in Section 3.

**Table 1. NPIs composing the french lockdown started on Oct 30th, 2020**

Intervention description	UFO-L Pattern	Legal Agent A	Legal Agent P
Non-essential businesses, such as restaurants and bars, will close	Right-Duty to an Omission	State	Site Owner
Leave home only for essential work or medical reasons	Right-Duty to an Omission	State	Citizen
Fill in a form to justify leaving home	Right-Duty to an Action	State	Citizen
Social gatherings are banned	Right-Duty to an Omission	State	Citizen

[9]https://www.zeit.de/politik/deutschland/2020-11/coronavirus-lockdown-light-jens-spahn-entlastung-gesundheitssystem

[10]We adopt the following color coding in the OntoUML diagrams: relators are represented in green, modes in blue, events in yellow, objects in pink, and classes whose instances might be of different ontological nature in gray.

Table 2. NPIs composing the german lockdown started on Nov 2nd, 2020

Intervention description	UFO-L Pattern	Legal Agent A	Legal Agent P
Restaurants and bars will close, except for take-away	Right-Duty to an Omission	State	Site Owner
Public recreation centers such as swimming pools, gyms and saunas will be closed	Right-Duty to an Omission	State	Site Owner
Entertainment facilities such as theaters and cinemas will be closed	Right-Duty to an Omission	State	Site Owner
All those who can work from home should do so	Right-Duty to an Omission (to leave home)	State	Employee
Employers should ease a transition into working from home	Right-Duty to an Action	Employers	Employee
Unnecessary travel is strongly discouraged	Right-Duty to an Omission	State	Citizen
Large events will be canceled	Right-Duty to an Omission	State	Event Organizer, Agent in charge
No crowds at sports events	Right-Duty to an Omission	State	Event Organizer, Citizen
Meetings in public will be restricted to just two households of up to 10 people total	Right-Duty to an Omission	State	Citizen
Overnight stays in hotels for tourist purposes is banned	Right-Duty to an Omission	Hotel Owner, Agent in Charge	Tourist
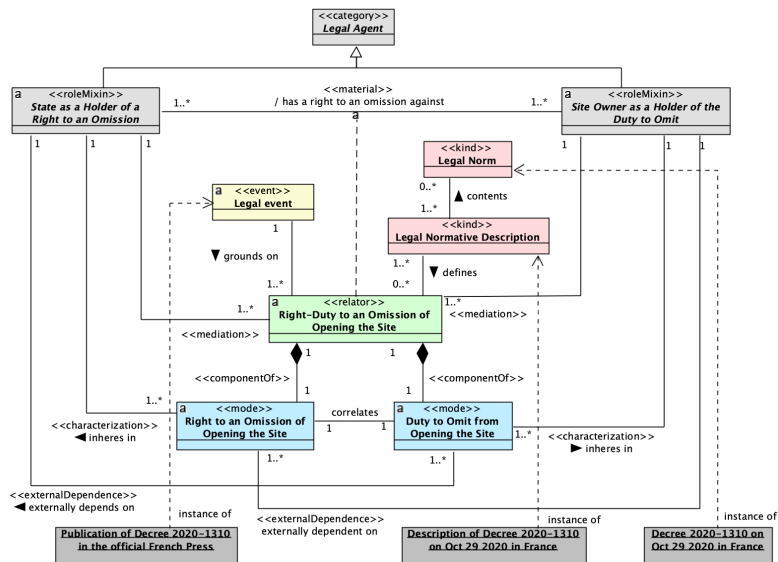
Figure 4. Instantiating the Right-Duty to an Omission UFO-L pattern to model the closure of sites inteduring the french lockdown
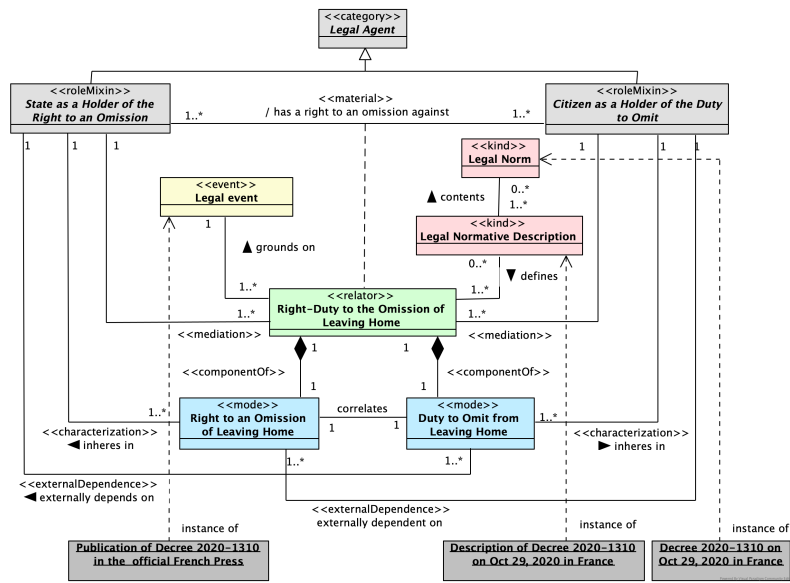
Figure 5. Instantiating the Right-Duty to an Omission UFO-L pattern to model the the stay at home intervention during the french lockdown

We also propose a new ontology for NPIs, illustrated in Figure 6, in which we define *Lockdown* as a complex NPI that is composed of other (either simple or complex) NPIs as its parts. So conceived, the parts that compose a specific lockdown may vary from one country/region to another, resulting in different compositions. We also noticed that several lockdown measures comprise interventions such as the closure of sites where non essential activities take place (such as restaurants, gyms and theatres), gathering cancellations, the need to justify leaving home, among others. Thus, representing a lockdown as a specialization of the *Travel Restriction NPI* category (Figure 1) does not do justice to the specific and subtle ways in which particular interventions can differ from each other.
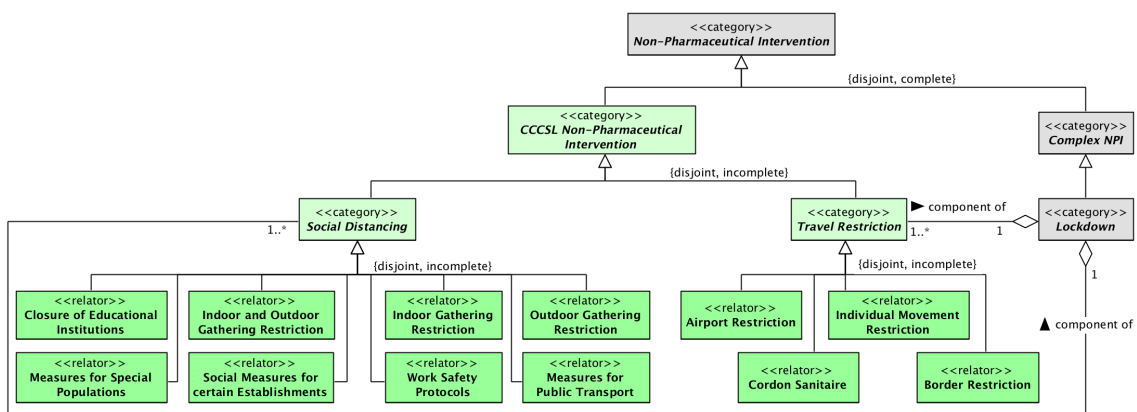

Figure 6. Proposed NPI ontology, focused on the Lockdown concept

5. Conclusion

The large amount of COVID-19 data available tells us a story, but to accurately understand the meaning of what is described in the data, semantic transparency is needed. In this direction, this paper provided an ontological analysis and conceptual clarification of

the notion of lockdown, in the context of the COVID-19 pandemic, providing a legal perspective for its definition, based on the UFO-L core ontology. Our ontological analysis helps us to confirm that the term lockdown is still a heavily overloaded and conceptually unclear notion that presents semantic distinctions in its definition from one country/region to another. This lack of semantic transparency affects the results of the analysis performed over data, thus making it difficult to compare and evaluate the efficacy of these interventions between regions and countries.

In this work, we propose an initial version of a domain ontology resulted from our analysis. The proposed ontology explicitly characterizes lockdown interventions in the context of the COVID-19 pandemic and represents several NPI types that compose lockdown interventions from a legal perspective. By doing that, it allows us to render explicit the existing semantic distinctions between different lockdown measures.

As future work, we plan to further validate our findings by expanding our analysis to different COVID-19 datasets, thus considering other regions/countries and additional non-pharmaceutical interventions. Furthermore, the proposed ontology will be evaluated by domain specialists with regard to its completeness and correctness against their textual descriptions. We also plan to apply our ontology to improve the quality of results obtained by the application of Data Science and Data Analytics techniques.

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