

The Gaps in the Terminological Representation of the ACORN Social Determinants of Health Survey

Melissa P. Resnick¹, Diane Montella², Wilmon McCray^{1,2}, Steven H. Brown², Keith E. Campbell², Jonathan Nebeker², Frank LeHouillier¹ and Peter L. Elkin^{1,2,3,4}

¹ Department of Biomedical Informatics, University at Buffalo, Buffalo, New York, USA

² U.S. Department of Veteran Affairs, Office of Health Informatics, Washington D.C., USA

³ U.S. Department of Veteran Affairs, WNY VA, Buffalo, New York, USA

⁴ Faculty of Engineering, University of Southern Denmark, Odense, Denmark

Abstract

Objective: Social Determinants of Health (SDOH) greatly influence health outcomes and healthcare utilization. Tools, such as the Assessing Circumstances & Offering Resources for Needs (ACORN) survey, have been developed to screen for SDOH. The purpose of this study is to determine the level of terminological representation of the ACORN survey by the Solor terminology. **Methods:** Each ACORN survey question was read to determine its concepts. Next, Solor was searched for each of the concepts and for the appropriate attributes. If no attributes or concepts existed, they were created. Then, each question's concepts and attributes were arranged into subject-relation-object triples. **Results:** Eleven unique attributes and 18 unique concepts were created. These results demonstrate a gap in representing SDOH with terminologies. We believe that using the Basic Formal Ontology (BFO) machinery to fill this gap will assist in bringing together the concepts to better represent SDOH.

Keywords¹

Social Determinants of Health, ACORN Screening Tool, Solor Terminology

1. Introduction

There has been an increased interest in Social Determinants of Health (SDOH) for over two decades [1]. This is due to the fact that they greatly influence health outcomes and healthcare utilization, thus, contributing to health disparities for disadvantaged individuals [2]. As noted by Powell (2019), SDOH affect health, behavioral health, and general quality of life [3].

Social Determinants of Health are the conditions in which individuals are born, grow, live, work, and age [3,4]. These SDOH occur across dimensions of functioning, such as, social, economic, and physical dimensions [3]. They also

occur in various environments and settings including: schools, places of employment, religious centers, and neighborhoods [3]. Examples of SDOH include: (1) opportunities for education and employment, (2) level of income, (3) access to housing and affordable utilities, (4) social and community support, and (5) access to transportation, just to name a few [5,6].

1.1. World Health Organization and SDOH

The World Health Organization (WHO) has three areas of work: (1) building the evidence for action; (2) promoting health in all policies and

¹ICBO 2022, September 25-28, 2022, Ann Arbor, MI, USA
EMAIL: mresnick@buffalo.edu (A. 1); diane.montella@va.gov (A. 2); wilmon.mccray@va.gov (A. 3); steven.brown@va.gov (A. 4); campbell@informatics.com (A. 5); jonathan.nebeker@va.gov (A. 6); fdl1@buffalo.edu (A. 7); elkinp@buffalo.edu (A. 8)
ORCID: 0000-0001-9699-852X (A. 1); 0000-0001-9396-8798 (A. 2); 0000-0001-6103-1845 (A. 4); 0000-0001-5355-5008 (A. 6); 0000-0002-2961-1273 (A. 7); 0000-0001-9616-6811 (A. 8)



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intersectoral action capacities; and (3) special initiative for action on social determinants of health for advancing health equity [7]. The area of "special initiative for action on social determinants of health for advancing health equity" is most applicable to our work and will be discussed in more detail. According to WHO, the goal of this initiative is: "to ensure that health equity is integrated into the development of social and economic policies, including its gender dimensions, to improve the social determinants of health for at least 20 million disadvantaged people in at least 12 countries" [8]. To begin working toward this goal, WHO appointed the Commission on Social Determinants of Health (CSDH) [9,10].

The CSDH set out to identify how the structure of societies are affecting population health, and what governments and public health can do to change it [9,10]. Through their work, the CSDH determined that the circumstances in which people live are shaped by the distribution of money, power and resources at global, national and local levels [11]. Keeping this in mind, they provided three key strategic directions for policy work in SDOH: (1) the need for strategies to address context; (2) intersectoral action; and (3) social participation and empowerment [10]. Thus, health outcomes cannot be achieved by merely acting in the health sector alone; actions in other sectors are critical as well [11].

1.2. Healthy People and SDOH

In 1979, Healthy People began as the Surgeon General's report on Disease Prevention and Health Promotion [12]. This was followed in 1980 by the first set of national 10-year objectives [12]. Since that time, successive objectives of Healthy People 2000 (released in 1990) and Healthy People 2010 (released in 2000) have identified emerging public health priorities, which have been aligned with health promotion strategies [12]. The objectives of Healthy People 2020 were broadened to include the influence of social environment on health outcomes [12].

Four overarching goals were recommended by Healthy People 2020 [12]. One of the four goals is to: "create social and physical environments that promote good health for all" [12,13]. To meet this goal, Healthy People 2020 began by developing a framework specifically for social determinants of health [13]. This framework consists of five determinants or key areas: (1)

economic stability; (2) education; (3) social and community context; (4) health and health care; and (5) neighborhood and built environment [13]. Each of these five areas encompasses key issues in SDOH as follows: (1) economic stability: employment, food insecurity, housing instability, poverty; (2) education: early childhood education and development, enrollment in higher education, high school graduation, language and literacy; (3) social and community context: civic participation, discrimination, incarceration, social cohesion; (4) health and health care: access to health care, access to primary care, health literacy; and (5) neighborhood and built environment: access to foods that support healthy eating patterns, crime and violence, environmental conditions, quality of housing [13]. This framework was used starting in 2010 to establish new SDOH objectives, and to identify the existing Healthy People objectives existing at that time that were relevant to SDOH [13]. Healthy People 2030 (released in 2020) added a fifth overarching goal, and expanded the wording of the goal addressing social determinants of health to: "Create social, physical, and economic environments that promote attaining the full potential for health and well-being for all" [14]. Downstream, the Healthy People SDOH objectives and the activities to achieve them will aid in identifying important resources and to enact public health policy at federal, state and local levels [13], and it is notable that the fifth overarching goal newly added with the release of Healthy People 2030 seeks to engage leaders and other key people who can design and promote "policies that improve the health and well-being of all" [14].

2. Screening Tools for SDOH

Various tools can be used to screen individuals for SDOH. These include, but are not limited to: WellRx [15]; Protocol for Responding to and Assessing Patient Assets, Risks, and Experiences (PRAPARE) [16]; and Assessing Circumstances & Offering Resources for Needs (ACORN) [17]. The ACORN survey is a relatively new tool for measuring SDOH. As such, little is known about the terminological representation of the questions in this survey. The aim of this research study is to begin to represent the questions of the ACORN survey using the Solor terminology. First, we turn to the ACORN screening tool.

2.1. The ACORN Screening Tool

One tool for measuring SDOH is the Accessing Circumstances & Offering Resources for Needs (ACORN) survey. In 2020, a 13-question survey to screen for SDOH was developed by the Veterans Health Administration (VHA) for use with Veterans [17,18]. This survey uses one question from the WellRx tool, one question from the PRAPARE tool and five questions from other sources. The remaining six questions were developed by the VHA. Veteran-specific topics on the ACORN survey include: (1) needing information about educational benefits for Veterans, and (2) setting up a video visit with a member of the VA care team [17]. Topics not specific to Veterans and not from other sources include: (1) legal issues, (2) feeling lonely or isolated, (3) having access to and being able to use a smartphone or a computer, and (4) having access to reliable and affordable Internet [17].

2.2. WellRx Screening Tool

In 2014, there was no widely available structured method intended or tested for healthcare providers to identify and capture SDOH in the outpatient primary care medicine setting [15]. WellRx, an 11-question screening tool for SDOH, was developed and piloted at the University of New Mexico for this purpose [15]. The questions encompass such topics as: (1) food insecurity, (2) access to housing, (3) affordability of utilities, (4) transportation, (5) employment, (6) education, and (7) safety [15].

2.3. The PRAPARE Screening Tool

The Protocol for Responding to and Assessing Patient Assets, Risks, and Experiences (PRAPARE) survey is a 21-question screening tool for SDOH [19]. In 2013, the National Association of Community Health Centers (NACHC) and partners launched a project to develop and implement a national standardized patient social determinants of health risk assessment protocol, PRAPARE [16]. With its implementation in 2016, PRAPARE provided a way to assess SDOH and to expedite actions at the individual, community, and health system levels [16]. PRAPARE covers most of the same topics as WellRx namely: (1) food security, (2) access to housing and utilities, (3) transportation, (4)

employment, and (5) education [16]. In addition, PRAPARE includes: (1) social and emotional health; (2) being insured or uninsured; (3) clothing needs; and (4) income, just to name a few [16].

3. Representing the Screening Tools

The use of these various screening tools for social determinants of health produces a wealth of data. These data are a valuable source of health information, but currently are not fully utilized by many clinicians [20]. In fact, knowing that a patient has trouble finding transportation, has a potentially unsafe relationship with someone close, is currently unemployed, or various other SDOH would assist healthcare providers to design treatment plans to best help the patient [20]. Watkins and colleagues (2020) point out the need for standardized SDOH for care delivery supported by electronic health records: "these SDOH must be gathered, represented, and stored in a standardized way before they can be leveraged by informatics tools designed for health providers" [20]. Terminologies, such as the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), Logical Observation Identifiers Names and Codes (LOINC), and RxNorm can be used to represent these SDOH screening tools and their resulting data.

Arons and colleagues (2018) performed preliminary work to determine how well concepts from six SDOH tools were covered in SNOMED CT, LOINC, ICD-10, and CPT [6]. These SDOH tools included: (1) the NAM's 2014 Recommended Social and Behavioral Domains and Measures report; (2) the PRAPARE survey; (3) the Accountable Health Communities (AHC) survey; (4) the Health Leads questionnaire; (5) the SEEK tool; and (6) the WE CARE survey [6]. They noted that although a large number of concepts from these SDOH tools are covered by standardized vocabularies, there exist some gaps [6]. Not surprisingly, Arons and colleagues (2018) demonstrated that the Education, Employment, Housing, Safety, and Social Connections/Isolation domains had particularly high numbers of codes, as these are well covered in SNOMED CT and LOINC [6]. However, domains such as child care, clothing, incarceration, immigration/migration, and Veteran status were found to be lacking codes [6].

The ACORN survey was created two years after Arons and colleagues published their work.

Thus, ACORN could not be included in their analysis. In addition, RxNorm was not included as one of the terminologies in their analysis. It is also possible that additional terms were added to any or all of the terminologies contained within the Solor terminology within the ensuing years. Therefore, the recent creation of the ACORN survey and the possibility of newly added SDOH-related terms to SNOMED CT, LOINC and RxNorm (Solor terminologies) provided the impetus for this research.

3.1. The Solor Terminology

Solor [21] is an integrated terminology system created in collaboration with the U.S. Dept. of Veterans Affairs (VA) that combines SNOMED CT (representing diseases, findings, and procedures), LOINC (representing laboratory test results), and RxNorm (representing medications) [22]. Solor has two fundamental building blocks: concepts with their synonyms, and semantics [22]. In this case, a concept is a medically-related idea, such as heart attack, while a semantic is data that provides contextual meaning to the concepts [22,23]. Like SNOMED CT, Solor is built on a logic model [22]. Most of the concepts are shared by Solor and SNOMED CT and are arranged into hierarchies using "is_a" relationships [22]. Therefore, the modeling is based on SNOMED CT, LOINC, and RxNorm.

As an integrated terminology system, Solor provides many advantages. For instance, this single consistent method of encoding clinical data can allow this data to flow among clinical documentation, decision support applications, and order entry at the point of care [22]. Solor can also support research, quality measurement, and other secondary uses [22].

At the current time, the Solor terminology is used in three different contexts. As noted by Resnick and colleagues (2021) it is used in a research setting [22]. Solor also provides Clinical Decision Support (CDS) modeling at the VA. In the third context, Solor is part of the Sentinel initiative at the Food and Drug Administration (FDA). Sentinel is the FDAs national electronic system which allows researchers to monitor the safety of FDA-regulated medical products, such as drugs, vaccines, biologics, and medical devices [24]. The Sentinel Initiative leverages organizational partnerships in informatics, data science (using natural language processing and machine learning) and other areas [24].

4. Methods

The Assessing Circumstances & Offering Resources for Needs (ACORN) survey was obtained [18]. Each survey question was read to discern all terms.

Next, Solor was searched for each of the identified ACORN terms. For those ACORN terms for which concepts were found to be present in Solor, the codes and names were noted. If the needed concept was not present in Solor, a "new" concept was created.

In the final step, Solor was searched for appropriate attributes in order to form subject-attribute-object triples. If no appropriate attributes existed, they were created.

5. Results

A total of 52 terms relating specifically to social determinants of health were identified from the ACORN survey questions. During the encoding process, 12 unique attributes were used: 1 unapproved SNOMED CT attribute and 11 newly created attributes (see Table 1).

Table 1
12 Unique Attributes Utilized

Unapproved SNOMED CT Attribute	Created Attribute
without (unapproved attribute)	experienced_by
	has_access_to
	has_behavior
	has_desire
	has_frequency
	has_lived_as
	has_lived_in
	has_lived_with
	has_need_for
	has_truth_value
	scheduled_for

A total of 34 unique concepts were used from the Solor terminologies. Of these, 20 were from SNOMED CT; 14 were from LOINC; and 0 were from RxNorm.

As seen in Table 2, 18 unique new SDOH concepts were created.

Table 2
18 Unique Concepts Created

Concept Created
Affordable internet at home
Apartment/House/ Room (no government subsidy)
Apartment/House/Room (with government subsidy)
As a part of household
Cell phone
Friend
Help getting food this week
Help learning to use computer
Help learning to use smartphone
Information about Veterans educational benefits
I don't want internet access at home
Information about Veterans educational resources
Reliable internet at home
Rented housing
Runs out of phone minutes
Smartphone
Steady place to stay
Worry about housing in near future

In Appendix A, two of the ACORN survey questions with their triples are shown. As shown in column 2, the subject of the triples are represented by concepts from SNOMED CT or LOINC. The same is true for the object of the triples, as seen in column 4. For these two survey questions, none of the created concepts, and three of the 11 created attributes were used to form the triples.

6. Discussion

Among the contributions of this work are the triples. These triples can be leveraged with at least two informatics tools: (1) Natural Language Processing (NLP) tools, and (2) Clinical Decision Support tools. In the case of NLP, the triples provide increased accuracy in tagging the unstructured text, which can influence other activities downstream. Triples also allow for the triggering of CDS rules, which in turn, can improve the care given to patients. Hence, it is for these reasons that the triples are created while encoding the ACORN survey.

The encoding of the ACORN survey questions revealed three issues: (1) the need to create new concepts; (2) concepts from more than one terminology that represent any one question; and (3) lack of appropriate attributes or relations. In one of the cases, however, it appeared that SNOMED CT attributes could be used. For example, it seemed possible to utilize "inheres_in" to create the triple: 267076002 feeling lonely (finding) "inheres_in" 116154003 patient (person). However, this is not possible, as SNOMED CT dictates that the domain of "inheres_in" needs to be an observable entity, not a finding [25]. Thus, a new attribute "experienced_by" was created.

Almost all of the attributes were created (see Table 1). This is most likely due to the fact that the relations or attributes for social determinants of health are not well represented in SNOMED CT, and thus, Solor. The lack of appropriate attributes demonstrates a gap in the representation of relations between the SDOH concepts.

A second issue involves the representation of the concepts for each question. Many of the questions are represented by concepts from two different Solor terminologies: SNOMED CT, and LOINC (see Appendix A). This, in turn, also contributed to the difficulty in finding appropriate attributes or relations to form the triples from these concepts. In other instances, the concepts do, indeed, exist in the same Solor terminology (see Appendix A). However, as shown in Appendix A, it is still necessary to use a created attribute in order to form the triples.

Finally, it was necessary to create some new concepts (see Table 2). In viewing these concepts, it appears that they represent housing, utilities and education. Once again, this demonstrates that there is a gap in the coverage of social determinants of health by the Solor terminologies: SNOMED CT, LOINC, and RxNorm.

Before moving on, a brief note must be made about the lack of RxNorm concepts. This is not necessarily a function of a gap in coverage. Rather, it is most likely due to the content of the questions. In fact, none of the questions ask about specific medications, thus, obviating the need for concepts from this Solor terminology.

There are at least two solutions to the previously discussed issues. First, the created attributes and concepts could be submitted for inclusion in SNOMED CT, which would also be included in Solor. Second, the Basic Formal Ontology (BFO) could be used to represent the created attributes and concepts. Once this has

been accomplished, the remaining concepts from the different terminologies for each question could be brought together using the BFO representations of the newly created attributes. By using the BFO machinery in this way, we would be able to fill in the gaps created by lack of appropriate SNOMED CT or Solor attributes.

The BFO is a realism-based, formal and domain-neutral upper level ontology that is designed to represent, at a very high level of generality, the types of entities in the world and the relations that exist between them [26]. Since it is intended to provide only the most basic building blocks for constructing domain-specific ontologies, it is very small [26]. In addition, it provides a starting point for the logical descriptions of the types of entities in a specific domain [26]. Thus, an advantage of utilizing the BFO is that the domain ontologies are, to a degree, interoperable [26].

A part of this research involves representing relations with the BFO. BFO has three basic relations: (1) those between two universals (as within the ontology itself); (2) those between a universal and a particular; and (3) those between two particulars [27]. Relations between a particular and a universal are used in cases where the ontology is applied to a portion of reality, as in the annotation of medical records for a group of patients [27]. Relations between two particulars are used when asserting that Mary's leg is a part of Mary [27].

Relations between universals have been further categorized as: (1) foundational relations, (2) spatial relations, (3) temporal relations, and (4) participation relations [27]. These have been formed into the relation Ontology, which has been used in many of the ontologies of the OBO Foundry [27,28]. This provides interoperability between many of the OBO Foundry ontologies [27].

Currently, we are beginning to investigate how the BFO can be used to represent the concepts and relations that we have created and identified. One of the challenges is that terminologies such as SNOMED CT and LOINC are concept-based [29], while BFO is realism-based [26,27]. As such, many of the terms representing the questions of the ACORN survey, along with the created terms and attributes, might not fit into the BFO framework. However, by expressing the identified terms and created terms and attributes in a realism-based way, it is believed that they can then be represented by the BFO framework. An example is discussed below.

Question six (6) of the ACORN survey reads: How often do you feel lonely or isolated from those around you? a. Often b. Sometimes c. Never [17]. Concepts for this question were found in SNOMED CT, and are as follows: (1) 116154003 patient (person); (2) 267076002 feeling lonely (finding); and (3) 307048004 feeling isolated (finding). For the reason previously discussed, the attribute "inheres_in" could not be used. Thus, since other appropriate attributes to express the triples were not found, two new attributes were created: "experienced_by", and "has_frequency". This allowed us to form such triples as: (1) 267076002 feeling lonely (finding) "experienced_by" 116154003 patient (person); and (2) 267076002 feeling lonely (finding) "has_frequency" LA10044-8 often. Using the BFO framework would allow us to express these triples without forming new concepts and attributes.

Using the BFO framework, "feeling lonely" would be a quality universal of which instances inhere in human beings. At every temporal region t at which there exists an instance x of "feeling lonely", there must exist a human being y in which x inheres. Temporal region t has two temporal-parts: temporal region t_1 and temporal region t_2 . Here, t_1 is composed of temporal intervals such that during these intervals there exists an instance of feeling lonely that inheres in a human being. Next, t_2 is composed of temporal intervals such that if at least one instance of feeling lonely exists during the interval, none of these instances inhere in a human being. The temporal-part of t_2 in which none inheres in a human being represents "a human being never feels lonely. In the case of a human being "feeling lonely often" t_1 is larger than t_2 . The representation for "a human being sometimes feeling lonely" is similar, except that t_1 is smaller than t_2 . A similar representation can be used for "feeling isolated".

Another ontology that may be helpful in our research is the Ontology of Medically Related Social Entities (OMRSE). The OMRSE is built upon the BFO, thus, conforming to the best practices of the OBO Foundry [30]. The OMRSE was originally developed to represent demographic data, but additionally includes representations for organizations, roles, facilities, demographic data, enrollment in insurance plans, and data about socio-economic indicators [30]. Currently, of particular interest are representations for "healthcare facilities", "households" and "housing units". The OMRSE is designed to bridge the gap between BFO and more

specific domain ontologies, as well as providing various classes for reuse in other ontologies [30]. As we move forward in our research, ontologies such as the OMRSE will assist in representing the information in and produced by the ACORN survey.

7. Conclusion

In conclusion, social determinants of health are not well represented by the Solor terminologies: SNOMED CT, LOINC, and RxNorm. This gap in representation is especially apparent with the attributes or relations. We believe that using the BFO machinery to represent these relations will assist in bringing together the concepts, even those from different terminologies, to better represent SDOH.

8. Future Work

In the future, we will submit the new attributes and concepts to SNOMED. In addition, we will begin to use BFO to properly express the information in the newly created concepts. As a part of this process, concise definitions and appropriate hierarchies will be created. From here, we will use the BFO to represent the information from the questions of the ACORN survey. Finally, it is hoped that this work will lay the foundation for conversations regarding the process of bringing SNOMED CT, LOINC, and RxNorm together to be represented by the BFO. This will require collaborations not only with those who understand BFO, but also those who understand SNOMED CT, LOINC, and RxNorm. By doing so, we can make strides toward interoperability between these three terminologies, and ultimately improve the care that we provide for patients.

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Appendix A

Two ACORN Questions with Encodings and Triples

ACORN Survey Question	Subject (SNOMED / LOINC)	Attribute (NEW [from Table1])	Object (SNOMED / LOINC)
(6) How often do you feel lonely or isolated from those around you? a. Often b. Sometimes c. Never	[SNOMED] 267076002 feeling lonely (finding)	"experienced_by"	[SNOMED] 116154003 patient (person)
	[SNOMED] 307048004 feeling isolated (finding)	"experienced_by"	[SNOMED] 116154003 patient (person)
	[SNOMED] 267076002 feeling lonely (finding)	"has_frequency"	[LOINC] LA10044-8 often
	[SNOMED] 267076002 feeling lonely (finding)	"has_frequency"	[LOINC] LA10082-8 sometimes
	[SNOMED] 267076002 feeling lonely (finding)	"has_frequency"	[LOINC] LA6270-8 never
	[SNOMED] 307048004 feeling isolated (finding)	"has_frequency"	[LOINC] LA10044-8 often
(7) How often does anyone close to you physically hurt you or threaten you with harm? a. Often b. Sometimes c. Never	[SNOMED] 3030701001 person in the family (person)	"has_behavior"	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)
	[SNOMED] 394863008 non-family member (person)	"has_behavior"	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)
	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)	"has_frequency"	[LOINC] LA10044-8 often
	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)	"has_frequency"	[LOINC] LA10082-8 sometimes
	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)	"has_frequency"	[LOINC] LA6270-8 never
	[LOINC] 95619-3 hurts, insults, threatens, and screams (hits)	"has_frequency"	[LOINC] LA6270-8 never