



## Mark Musen

Stanford Medicine Professor of Biomedical Informatics Research, Professor of Medicine (Biomedical Informatics) and of Biomedical Data Science

Medicine - Biomedical Informatics Research

 NIH Biosketch available Online

### Bio

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#### BIO

Dr. Musen is Professor of Biomedical Informatics at Stanford University, where he is Director of the Stanford Center for Biomedical Informatics Research. Dr. Musen conducts research related to open science, data stewardship, intelligent systems, and biomedical decision support. His group developed Protégé, the world's most widely used technology for building and managing terminologies and ontologies. He is principal investigator of the National Center for Biomedical Ontology, one of the original National Centers for Biomedical Computing created by the U.S. National Institutes of Health (NIH). He is principal investigator of the Center for Expanded Data Annotation and Retrieval (CEDAR). CEDAR develops new technology to ease the authoring and management of biomedical experimental data and metadata to make online datasets more findable, accessible, interoperable, and reusable. Dr. Musen chaired the Health Informatics and Modeling Topic Advisory Group for the World Health Organization's revision of the International Classification of Diseases (ICD-11) and he currently directs the WHO Collaborating Center for Classification, Terminology, and Standards at Stanford University.

Early in his career, Dr. Musen received the Young Investigator Award for Research in Medical Knowledge Systems from the American Association of Medical Systems and Informatics and a Young Investigator Award from the National Science Foundation. In 2006, he was recipient of the Donald A. B. Lindberg Award for Innovation in Informatics from the American Medical Informatics Association. He has been elected to the American College of Medical Informatics, the Association of American Physicians, the International Academy of Health Sciences Informatics, and the National Academy of Medicine. He is founding co-editor-in-chief of the journal Applied Ontology.

#### ACADEMIC APPOINTMENTS

- Professor, Medicine - Biomedical Informatics Research
- Professor, Biomedical Data Science
- Member, Bio-X
- Faculty Affiliate, Institute for Human-Centered Artificial Intelligence (HAI)

#### ADMINISTRATIVE APPOINTMENTS

- Principal Investigator, RADx Data Hub, (2021- present)
- Principal Investigator, Center for Expanded Data Annotation and Retrieval, (2014- present)
- Principal Investigator, National Center for Biomedical Ontology, (2005- present)
- Co-Editor-in-Chief, Applied Ontology: An International Journal of Ontological Analysis and Conceptual Modeling, (2005-2016)
- Deputy Director for Bioinformatics, Immune Tolerance Network, (2005-2007)
- Head, Stanford Center for Biomedical Informatics Research, (1992- present)

## HONORS AND AWARDS

- Doctor honoris causa, University of Fribourg, Switzerland (2023)
- Doctor honoris causa, University of A Coruña, Spain (2021)
- Elected member, International Academy of Health Sciences Informatics (2017)
- Elected member, National Academy of Medicine (2016)
- "Ten Year Award" for the most influential paper presented at ISWC, ten years previously, Semantic Web Science Association (2014)
- General Chair, Association for Computing Machinery Conference on Knowledge Capture (K-Cap '11) (2011)
- Elected member, Association of American Physicians (2010)
- Donald A. B. Lindberg Award for Innovation in Informatics, American Medical Informatics Association (2006)
- General Chair, International Semantic Web Conference (2005)
- Chair, Scientific Program Committee, American Medical Informatics Association Annual Symposium (2003)
- Elected member, American Society for Clinical Investigation (1997)
- NSF Young Investigator Award, National Science Foundation (1992)
- Elected Fellow, American College of Medical Informatics (1989)
- Young Investigator Award for Research in Medical Knowledge Systems, American Association for Medical Systems and Informatics (1989)

## BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Member, U.S. National Committee for CODATA (2020 - present)
- Member, National Advisory Council on Biomedical Imaging and Bioengineering (2011 - 2015)
- Chair, Health Informatics and Modeling Topic Advisory Group, ICD Revision Steering Group, World Health Organization (2008 - 2016)

## PROGRAM AFFILIATIONS

- Symbolic Systems Program

## PROFESSIONAL EDUCATION

- Postdoctoral fellow, Erasmus University, Rotterdam , Medical Informatics (1988)
- Ph.D., Stanford University , Medical Information Sciences (1988)
- Residency, Stanford University Hospital , Internal Medicine (1983)
- M.D., Brown University , Medicine (1980)
- Sc.B., Brown University , Biology (1977)

## LINKS

- The Center for Expanded Data Annotation and Retrieval: <http://metadatascenter.org>
- The National Center for Biomedical Ontology: <http://bioontology.org>
- The Protégé resource: <http://protege.stanford.edu>

## Research & Scholarship

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### CURRENT RESEARCH AND SCHOLARLY INTERESTS

Semantic technology, which makes explicit the knowledge that drives computational systems, offers great opportunities to advance biomedical science and clinical medicine. Our laboratory studies the use of semantic technology in a range of application systems, emphasizing approaches that enhance the stewardship and dissemination of experimental datasets for open science.

The Center for Expanded Data Annotation and Retrieval (CEDAR) investigates new computational approaches that use semantic technology to ease the creation of metadata to describe scientific experiments. Metadata are data about data—machine-actionable descriptions of experimental data, of the methods used to acquire the data, of the analyses that have been performed on the data, and of the provenance of all this information. Science suffers because much of the metadata that investigators create to annotate the datasets that they archive in public repositories are incomplete and nonstandardized. CEDAR studies new methods to assist the authoring of high-quality metadata. Our long-term goal is to aid the dissemination of scientific data and knowledge in machine-processable form, and to create intelligent agents that can help scientists to track experimental results online, to integrate datasets, and to use public data repositories to make new discoveries.

We see CEDAR as the first step in the development of a new kind of technology to change the way in which scientific knowledge is communicated—not as prose journal articles but as computer-interpretable data and metadata. Automated systems one day will access such online "publications" to augment the capabilities of human scientists as they seek information about relevant studies and as they attempt to relate their own results to those of other investigators.

Our laboratory has pioneered methods for the development of intelligent systems. An important element of this work has involved the use of ontologies—formal descriptions of application areas that are created in a form that can be processed by both people and computers. CEDAR uses ontologies to ensure that scientific metadata are represented in a standardized way. Our Protégé system for ontology development—now with more than 400,000 registered users—allows us to continue to explore new methods for ontology engineering and for the construction of intelligent systems and knowledge graphs.

## Teaching

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### COURSES

#### 2023-24

- Digital Health Practicum in a Health Care Delivery System: BIOMEDIN 226 (Spr)
- Mathematical Models and Medical Decisions: BIOMEDIN 219 (Win)
- Modeling Biomedical Systems: BIOMEDIN 210, CS 270 (Win, Spr)

#### 2022-23

- Digital Health Practicum in a Health Care Delivery System: BIOMEDIN 226 (Spr, Sum)
- Modeling Biomedical Systems: BIOMEDIN 210, CS 270 (Win, Spr)

#### 2021-22

- Digital Health Practicum in a Health Care Delivery System: BIOMEDIN 226 (Spr, Sum)
- Modeling Biomedical Systems: BIOMEDIN 210, CS 270 (Win, Spr)

#### 2020-21

- Digital Health Practicum in a Health Care Delivery System: BIOMEDIN 226 (Win, Spr)
- Modeling Biomedical Systems: BIOMEDIN 210, CS 270 (Win)

### STANFORD ADVISEES

#### Postdoctoral Faculty Sponsor

Christian Kindermann, Sowmya Somasundaram

#### Master's Program Advisor

Adyant Shankar

#### Postdoctoral Research Mentor

Tushar Mungle

Doctoral (Program)

Eric Sun

## GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Biomedical Informatics (Masters Program)
- Biomedical Informatics (Phd Program)
- Health Services Research (Masters Program)
- Medicine (Masters Program)

## Publications

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### PUBLICATIONS

- **Modeling community standards for metadata as templates makes data FAIR.** *Scientific data*  
Musen, M. A., O'Connor, M. J., Schultes, E., Martinez-Romero, M., Hardi, J., Graybeal, J.  
2022; 9 (1): 696
- **Demand standards to sort FAIR data from foul** *NATURE*  
Musen, M. A.  
2022; 609 (7926): 222
- **The variable quality of metadata about biological samples used in biomedical experiments.** *Scientific data*  
Goncalves, R. S., Musen, M. A.  
2019; 6: 190021
- **Aligning Biomedical Metadata with Ontologies Using Clustering and Embeddings**  
Goncalves, R. S., Kamdar, M. R., Musen, M. A., Hitzler, P., Fernandez, M., Janowicz, K., Zaveri, A., Gray, A. J., Lopez, Haller, A., Hammar, K.  
SPRINGER INTERNATIONAL PUBLISHING AG.2019: 146–61
- **Interpretation of biological experiments changes with evolution of the Gene Ontology and its annotations** *SCIENTIFIC REPORTS*  
Tomczak, A., Mortensen, J. M., Winnenburg, R., Liu, C., Alessi, D. T., Swamy, V., Vallania, F., Lofgren, S., Haynes, W., Shah, N. H., Musen, M. A., Khatri, P.  
2018; 8: 5115
- **The center for expanded data annotation and retrieval.** *Journal of the American Medical Informatics Association*  
Musen, M. A., Bean, C. A., Cheung, K., Dumontier, M., Durante, K. A., Gevaert, O., Gonzalez-Beltran, A., Khatri, P., Kleinstein, S. H., O'Connor, M. J., Pouliot, Y., Rocca-Serra, P., Sansone, et al  
2015; 22 (6): 1148-1152
- **The Protégé Project: A Look Back and a Look Forward.** *AI matters*  
Musen, M. A.  
2015; 1 (4): 4-12
- **The National Center for Biomedical Ontology** *JOURNAL OF THE AMERICAN MEDICAL INFORMATICS ASSOCIATION*  
Musen, M. A., Noy, N. F., Shah, N. H., Whetzel, P. L., Chute, C. G., Story, M., Smith, B.  
2012; 19 (2): 190-195
- **Advances and prospects for the Human BioMolecular Atlas Program (HuBMAP).** *Nature cell biology*  
Jain, S., Pei, L., Spraggins, J. M., Angelo, M., Carson, J. P., Gehlenborg, N., Ginty, F., Gonçalves, J. P., Hagood, J. S., Hickey, J. W., Kelleher, N. L., Laurent, L. C., Lin, et al  
2023
- **Specimen, biological structure, and spatial ontologies in support of a Human Reference Atlas.** *Scientific data*  
Herr, B. W., Hardi, J., Quardokus, E. M., Bueckle, A., Chen, L., Wang, F., Caron, A. R., Osumi-Sutherland, D., Musen, M. A., Börner, K.  
2023; 10 (1): 171

- **The scalable precision medicine open knowledge engine (SPOKE): A massive knowledge graph of biomedical information.** *Bioinformatics (Oxford, England)*  
Morris, J. H., Soman, K., Akbas, R. E., Zhou, X., Smith, B., Meng, E. C., Huang, C. C., Ceroni, G., Schenk, G., Rizk-Jackson, A., Harroud, A., Sanders, L., Costes, et al  
2023
- **A biomedical open knowledge network harnesses the power of AI to understand deep human biology.** *AI magazine*  
Baranzini, S. E., Börner, K., Morris, J., Nelson, C. A., Soman, K., Schleimer, E., Keiser, M., Musen, M., Pearce, R., Reza, T., Smith, B., Herr, B. W., Oskotsky, et al  
2022; 43 (1): 46-58
- **An Architecture for Attesting to the Provenance of Ontologies Using Blockchain Technologies**  
Curty, S., Fill, H., Goncalves, R. S., Musen, M. A., Shishkov, B.  
SPRINGER INTERNATIONAL PUBLISHING AG.2022: 182-199
- **Using ethnographic methods to classify the human experience in medicine: a case study of the presence ontology.** *Journal of the American Medical Informatics Association : JAMIA*  
Maitra, A., Kamdar, M. R., Zulman, D. M., Haverfield, M. C., Brown-Johnson, C., Schwartz, R., Israni, S. T., Verghese, A., Musen, M. A.  
2021
- **Design of a FAIR digital data health infrastructure in Africa for COVID-19 reporting and research.** *Advanced genetics (Hoboken, N.J.)*  
van Reisen, M., Oladipo, F., Stokmans, M., Mpezamihgo, M., Folorunso, S., Schultes, E., Basajja, M., Aktau, A., Amare, S. Y., Taye, G. T., Purnama Jati, P. H., Chindoza, K., Wirtz, et al  
2021; 2 (2): e10050
- **An empirical meta-analysis of the life sciences linked open data on the web.** *Scientific data*  
Kamdar, M. R., Musen, M. A.  
2021; 8 (1): 24
- **FAIR Convergence Matrix: Optimizing the Reuse of Existing FAIR-Related Resources** *DATA INTELLIGENCE*  
Sustkova, H., Hettne, K., Wittenburg, P., Jacobsen, A., Kuhn, T., Pergl, R., Slifka, J., McQuilton, P., Magagna, B., Sansone, S., Stocker, M., Imming, M., Lannom, et al  
2020; 2 (1-2): 158-170
- **OrderRex clinical user testing: a randomized trial of recommender system decision support on simulated cases.** *Journal of the American Medical Informatics Association : JAMIA*  
Kumar, A., Aikens, R. C., Hom, J., Shieh, L., Chiang, J., Morales, D., Saini, D., Musen, M., Baiocchi, M., Altman, R., Goldstein, M. K., Asch, S., Chen, et al  
2020
- **Toward a Harmonized WHO Family of International Classifications Content Model.** *Studies in health technology and informatics*  
Tu, S. W., Nyulas, C. I., Tudorache, T., Musen, M. A., Martinuzzi, A., van Gool, C., Mea, V. D., Chute, C. G., Frattura, L., Hardiker, N., Napel, H. T., Madden, R., Almborg, et al  
2020; 270: 1409–10
- **A more decentralized vision for Linked Data** *SEMANTIC WEB*  
Polleres, A., Kamdar, M., Fernandez, J., Tudorache, T., Musen, M.  
2020; 11 (1): 101–13
- **Obstacles to the reuse of study metadata in ClinicalTrials.gov.** *Scientific data*  
Miron, L. n., Gonçalves, R. S., Musen, M. A.  
2020; 7 (1): 443
- **Physician Usage and Acceptance of a Machine Learning Recommender System for Simulated Clinical Order Entry.** *AMIA Joint Summits on Translational Science proceedings. AMIA Joint Summits on Translational Science*  
Chiang, J., Kumar, A., Morales, D., Saini, D., Hom, J., Shieh, L., Musen, M., Goldstein, M. K., Chen, J. H.  
2020; 2020: 89–97
- **WebProtege: A Cloud-Based Ontology Editor**  
Horridge, M., Goncalves, R. S., Nyulas, C. I., Tudorache, T., Musen, M. A., ACM  
ASSOC COMPUTING MACHINERY.2019: 686–89

- **Use of OWL and Semantic Web Technologies at Pinterest**  
Goncalves, R. S., Horridge, M., Li, R., Liu, Y., Musen, M. A., Nyulas, C. I., Obamos, E., Shrouly, D., Temple, D., Ghidini, C., Hartig, O., Maleshkova, M., Svatek, et al  
SPRINGER INTERNATIONAL PUBLISHING AG.2019: 418–35
- **Enabling Web-scale data integration in biomedicine through Linked Open Data.** *NPJ digital medicine*  
Kamdar, M. R., Fernandez, J. D., Polleres, A., Tudorache, T., Musen, M. A.  
2019; 2: 90
- **Unleashing the value of Common Data Elements through the CEDAR Workbench.** *AMIA ... Annual Symposium proceedings. AMIA Symposium*  
O'Connor, M. J., Warzel, D. B., Martínez-Romero, M. n., Hardi, J. n., Willrett, D. n., Egyedi, A. L., Eftekhari, A. n., Graybeal, J. n., Musen, M. A.  
2019; 2019: 681–90
- **HopRank: How Semantic Structure Influences Teleportation in PageRank (A Case Study on BioPortal)**  
Espin-Noboa, L., Lemmerich, F., Walk, S., Strohmaier, M., Musen, M., Assoc Comp Machinery  
ASSOC COMPUTING MACHINERY.2019: 2708–14
- **Using association rule mining and ontologies to generate metadata recommendations from multiple biomedical databases.** *Database : the journal of biological databases and curation*  
Martinez-Romero, M., O'Connor, M. J., Egyedi, A. L., Willrett, D., Hardi, J., Graybeal, J., Musen, M. A.  
2019; 2019
- **The CAIRR Pipeline for Submitting Standards-Compliant B and T Cell Receptor Repertoire Sequencing Studies to the National Center for Biotechnology Information Repositories** *FRONTIERS IN IMMUNOLOGY*  
Bukhari, S., O'Connor, M. J., Martinez-Romero, M., Egyedi, A. L., Willrett, D., Graybeal, J., Musen, M. A., Rubelt, F., Cheung, K., Kleinstein, S. H.  
2018; 9
- **The CAIRR Pipeline for Submitting Standards-Compliant B and T Cell Receptor Repertoire Sequencing Studies to the National Center for Biotechnology Information Repositories.** *Frontiers in immunology*  
Bukhari, S. A., O'Connor, M. J., Martínez-Romero, M., Egyedi, A. L., Willrett, D., Graybeal, J., Musen, M. A., Rubelt, F., Cheung, K. H., Kleinstein, S. H.  
2018; 9: 1877
- **CEDAR OnDemand: a browser extension to generate ontology-based scientific metadata** *BMC BIOINFORMATICS*  
Bukhari, S., Martinez-Romero, M., Connor, M., Egyedi, A. L., Willrett, D., Graybeal, J., Musen, M. A., Cheung, K., Kleinstein, S. H.  
2018; 19: 268
- **Analyzing user interactions with biomedical ontologies: A visual perspective** *JOURNAL OF WEB SEMANTICS*  
Kamdar, M. R., Walk, S., Tudorache, T., Musen, M. A.  
2018; 49: 16–30
- **AgroPortal: A vocabulary and ontology repository for agronomy** *COMPUTERS AND ELECTRONICS IN AGRICULTURE*  
Jonquet, C., Toulet, A., Arnaud, E., Aubin, S., Yeumo, E., Emonet, V., Graybeal, J., Laporte, M., Musen, M. A., Pesce, V., Larmande, P.  
2018; 144: 126–43
- **How Sustainable are Biomedical Ontologies?** *AMIA ... Annual Symposium proceedings. AMIA Symposium*  
Geller, J., Keloth, V. K., Musen, M. A.  
2018; 2018: 470–79
- **BiOnIC: A Catalog of User Interactions with Biomedical Ontologies.** *The semantic Web--ISWC ... : ... International Semantic Web Conference ... proceedings. International Semantic Web Conference*  
Kamdar, M. R., Walk, S., Tudorache, T., Musen, M. A.  
2017; 10588: 130-138
- **The CEDAR Workbench: An Ontology-Assisted Environment for Authoring Metadata that Describe Scientific Experiments.** *The semantic Web--ISWC ... : ... International Semantic Web Conference ... proceedings. International Semantic Web Conference*  
Gonçalves, R. S., O'Connor, M. J., Martínez-Romero, M., Egyedi, A. L., Willrett, D., Graybeal, J., Musen, M. A.  
2017; 10588: 103-110
- **An ontology-driven tool for structured data acquisition using Web forms** *JOURNAL OF BIOMEDICAL SEMANTICS*  
Goncalves, R. S., Tu, S. W., Nyulas, C. I., Tierney, M. J., Musen, M. A.

2017; 8: 26

- **NCBO Ontology Recommender 2.0: an enhanced approach for biomedical ontology recommendation.** *Journal of biomedical semantics*  
Martínez-Romero, M., Jonquet, C., O'Connor, M. J., Graybeal, J., Pazos, A., Musen, M. A.  
2017; 8 (1): 21-?
- **An Empirical Analysis of Ontology Reuse in BioPortal.** *Journal of biomedical informatics*  
Ochs, C., Perl, Y., Geller, J., Arabandi, S., Tudorache, T., Musen, M. A.  
2017
- **PhLeGrA: Graph Analytics in Pharmacology over the Web of Life Sciences Linked Open Data.** *Proceedings of the ... International World-Wide Web Conference. International WWW Conference*  
Kamdar, M. R., Musen, M. A.  
2017; 2017: 321-329
- **Use of Ontology Structure and Bayesian Models to Aid the Crowdsourcing of ICD-11 Sanctioning Rules.** *Journal of biomedical informatics*  
Lou, Y., Tu, S. W., Nyulas, C., Tudorache, T., Chalmers, R. J., Musen, M. A.  
2017
- **A systematic analysis of term reuse and term overlap across biomedical ontologies** *SEMANTIC WEB*  
Kamdar, M. R., Tudorache, T., Musen, M. A.  
2017; 8 (6): 853-71
- **The New HIT: Human Health Information Technology**  
Leung, T. I., Goldstein, M. K., Musen, M. A., Cronkite, R., Chen, J. H., Gottlieb, A., Leitersdorf, E., Gundlapalli, A. V., Jaulent, M. C., Zhao, D.  
IOS PRESS.2017: 768-72
- **High-Risk Drug-Drug Interactions Between Clinical Practice Guidelines for Management of Chronic Conditions.** *AMIA Joint Summits on Translational Science proceedings. AMIA Joint Summits on Translational Science*  
Tso, G. J., Tu, S. W., Musen, M. A., Goldstein, M. K.  
2017; 2017: 531-39
- **Precision annotation of digital samples in NCBI's gene expression omnibus.** *Scientific data*  
Hadley, D. n., Pan, J. n., El-Sayed, O. n., Aljabban, J. n., Aljabban, I. n., Azad, T. D., Hadied, M. O., Raza, S. n., Rayikanti, B. A., Chen, B. n., Paik, H. n., Aran, D. n., Spatz, et al  
2017; 4: 170125
- **Fast and Accurate Metadata Authoring Using Ontology-Based Recommendations.** *AMIA ... Annual Symposium proceedings. AMIA Symposium*  
Martinez-Romero, M., O'Connor, M. J., Shankar, R. D., Panahiazar, M., Willrett, D., Egyedi, A. L., Gevaert, O., Graybeal, J., Musen, M. A.  
2017; 2017: 1272-81
- **Mechanism-based Pharmacovigilance over the Life Sciences Linked Open Data Cloud.** *AMIA ... Annual Symposium proceedings. AMIA Symposium*  
Kamdar, M. R., Musen, M. A.  
2017; 2017: 1014-23
- **A unified software framework for deriving, visualizing, and exploring abstraction networks for ontologies.** *Journal of biomedical informatics*  
Ochs, C., Geller, J., Perl, Y., Musen, M. A.  
2016; 62: 90-105
- **Utilizing a structural meta-ontology for family-based quality assurance of the BioPortal ontologies.** *Journal of biomedical informatics*  
Ochs, C., He, Z., Zheng, L., Geller, J., Perl, Y., Hripcsak, G., Musen, M. A.  
2016; 61: 63-76
- **Utilizing a structural meta-ontology for family-based of the BioPortal ontologies** *JOURNAL OF BIOMEDICAL INFORMATICS*  
Ochs, C., He, Z., Zheng, L., Geller, J., Perl, Y., Hripcsak, G., Musen, M. A.  
2016; 61: 63-76
- **Is the crowd better as an assistant or a replacement in ontology engineering? An exploration through the lens of the Gene Ontology.** *Journal of biomedical informatics*  
Mortensen, J. M., Telis, N., Hughey, J. J., Fan-Minogue, H., Van Auken, K., Dumontier, M., Musen, M. A.  
2016; 60: 199-209

- **An Open Repository Model for Acquiring Knowledge About Scientific Experiments**  
O'Connor, M. J., Martnez-Romero, M., Egyedi, A. L., Willrett, D., Graybeal, J., Musen, M. A., Blomqvist, E., Ciancarini, P., Poggi, F., Vitali, F.  
SPRINGER INT PUBLISHING AG.2016: 762–77
- **Snap-SPARQL: A Java Framework for Working with SPARQL and OWL**  
Horridge, M., Musen, M., Tamma, Dragoni, M., Goncalves, R., Lawrynowicz, A.  
SPRINGER INT PUBLISHING AG.2016: 154–65
- **How to apply Markov chains for modeling sequential edit patterns in collaborative ontology-engineering projects** *INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES*  
Walk, S., Singer, P., Strohmaier, M., Helic, D., Noy, N. F., Musen, M. A.  
2015; 84: 51-66
- **Using ontologies to model human navigation behavior in information networks: A study based on Wikipedia.** *Semantic web*  
Lamprecht, D., Strohmaier, M., Helic, D., Nyulas, C., Tudorache, T., Noy, N. F., Musen, M. A.  
2015; 6 (4): 403-422
- **Investigating Term Reuse and Overlap in Biomedical Ontologies.** *CEUR workshop proceedings*  
Kamdar, M. R., Tudorache, T., Musen, M. A.  
2015; 1515
- **Analysis and Prediction of User Editing Patterns in Ontology Development Projects.** *Journal on data semantics*  
Wang, H., Tudorache, T., Dou, D., Noy, N. F., Musen, M. A.  
2015; 4 (2): 117-132
- **Using the wisdom of the crowds to find critical errors in biomedical ontologies: a study of SNOMED CT.** *Journal of the American Medical Informatics Association*  
Mortensen, J. M., Minty, E. P., Januszyk, M., Sweeney, T. E., Rector, A. L., Noy, N. F., Musen, M. A.  
2015; 22 (3): 640-648
- **Data breaches of protected health information in the United States.** *JAMA*  
Liu, V., Musen, M. A., Chou, T.  
2015; 313 (14): 1471-1473
- **Using ontologies to model human navigation behavior in information networks: A study based on Wikipedia** *SEMANTIC WEB*  
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2015; 6 (4): 403-422
- **Applied ontology: The next decade begins** *APPLIED ONTOLOGY*  
Guarino, N., Musen, M.  
2015; 10 (1): 1–4
- **Understanding How Users Edit Ontologies: Comparing Hypotheses About Four Real-World Projects**  
Walk, S., Singer, P., Nobao, L., Tudorache, T., Musen, M. A., Strohmaier, M., Arenas, M., Corcho, O., Simperl, E., Strohmaier, M., DAquin, M., Srinivas, K., Groth, et al  
SPRINGER INT PUBLISHING AG.2015: 551–68
- **User Extensible System to Identify Problems in OWL Ontologies and SWRL Rules**  
Orlando, J., Musen, M. A., Moreira, D. A., Bassiliades, N., Gottlob, G., Sadri, F., Paschke, A., Roman, D.  
SPRINGER-VERLAG BERLIN.2015: 112–26
- **Using Aggregate Taxonomies to Summarize SNOMED CT Evolution**  
Ochs, C., Perl, Y., Geller, J., Musen, M., Huan, J., Miyano, S., Shehu, A., Hu, Ma, B., Rajasekaran, S., Gombar, V. K., Schapranow, I. M., Yoo, I. H., et al  
IEEE.2015: 1008–15
- **Ten years of Applied Ontology** *APPLIED ONTOLOGY*  
Guarino, N., Musen, M. A.  
2015; 10 (3-4): 169–70
- **Helping Users Bootstrap Ontologies: An Empirical Investigation**



- Zhang, Y., Tudorache, T., Horridge, M., Musen, M. A., Assoc Comp Machinery  
ASSOC COMPUTING MACHINERY.2015: 3395–98
- **Toward a science of learning systems: a research agenda for the high-functioning Learning Health System** *JOURNAL OF THE AMERICAN MEDICAL INFORMATICS ASSOCIATION*  
Friedman, C., Rubin, J., Brown, J., Buntin, M., Corn, M., Etheredge, L., Gunter, C., Musen, M., Platt, R., Stead, W., Sullivan, K., Van Houweling, D.  
2015; 22 (1): 43-50
  - **A Method to Compare ICF and SNOMED CT for Coverage of U.S. Social Security Administration's Disability Listing Criteria.** *AMIA ... Annual Symposium proceedings / AMIA Symposium. AMIA Symposium*  
Tu, S. W., Nyulas, C. I., Tudorache, T., Musen, M. A.  
2015; 2015: 1224-1233
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