



STM Innovations Seminar 2010  
Flows in Flux: how publishing technologies  
change the researcher's life

3 December 2010



## Enriching scientific citations to facilitate knowledge discovery

David Shotton

Image Bioinformatics Research Group

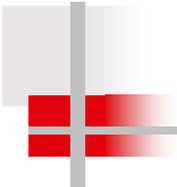
Department of Zoology

University of Oxford, UK

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*"It is a very sad thing  
that nowadays there is  
so little useless information"*

Oscar Wilde



## The importance of bibliographic citations

---

- The act of citation of others' preceding work is a central social process in the practice of science, formalized in the reference lists that typically conclude journal articles
- In this brief presentations, I will examine ways in which bibliographic citations may be enhanced in value
  - The SPAR Semantic Publishing and Referencing Ontologies
  - Citations in Context
  - The Open Citations Project



## Semantic publishing

“The use of simple Web and Semantic Web technologies to enhance the meaning of on-line research articles, so that information can more easily be found, extracted, combined and reused”

The exemplar article we chose to semantically ‘enliven’



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TROPICAL DISEASES**

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RESEARCH ARTICLE

OPEN  ACCESS

# Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums

Renato B. Reis<sup>1#</sup>, Guilherme S. Ribeiro<sup>1#</sup>, Ridalva D. M. Felzemburgh<sup>1</sup>, Francisco S. Santana<sup>1,2</sup>, Sharif Mohr<sup>1</sup>, Astrid X. T. O. Melendez<sup>1</sup>, Adriano Queiroz<sup>1</sup>, Andréia C. Santos<sup>1</sup>, Romy R. Ravines<sup>3</sup>, Wagner S. Tassinari<sup>3,4</sup>, Marília S. Carvalho<sup>3</sup>, Mitermayer G. Reis<sup>1</sup>, Albert I. Ko<sup>1,5\*</sup>

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**Citation:** PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.0000228

**Received:** January 22, 2008; **Accepted:** March 27, 2008; **Published:** April 23, 2008

# The enhanced *PLoS NTDs* paper by Reis *et al.* (2008)

<http://dx.doi.org/10.1371/journal.pntd.0000228.x001>

turn all highlighting on

date

disease

habitat

institution

organism

person

place

protein

taxon

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SEMANTICALLY ENHANCED VERSION OF A RESEARCH ARTICLE FROM PLOS NEGLECTED TROPICAL DISEASES

## Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums

[document summary](#)

Renato B. Reis <sup>1#</sup>, Guilherme S. Ribeiro <sup>1#</sup>, Ridalva D. M. Felzemburgh <sup>1</sup>, Francisco S. Santana <sup>1, 2</sup>, Sharif Mohr <sup>1</sup>, Astrid X. T. O. Melendez <sup>1</sup>, Adriano Queiroz <sup>1</sup>, Andréia C. Santos <sup>1</sup>, Romy R. Ravines <sup>3</sup>, Wagner S. Tassinari <sup>3, 4</sup>, Marília S. Carvalho <sup>3</sup>, Mitermayer G. Reis <sup>1</sup>, Albert I. Ko <sup>1, 5\*</sup>

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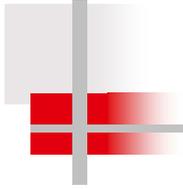
### Abstract

#### Background

Leptospirosis has become an urban health problem as slum settlements have expanded worldwide. Efforts to identify interventions for urban leptospirosis have been hampered by the lack of population-based information on *Leptospira* transmission determinants. The aim of the study was to estimate the prevalence of *Leptospira* infection and identify risk factors for infection in the urban slum setting.

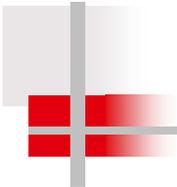
#### Methods and Findings

We performed a community-based survey of 3,171 slum residents from Salvador, Brazil. *Leptospira* agglutinating antibodies were measured as a marker for prior infection. Poisson regression models evaluated the association between the presence of *Leptospira* antibodies and environmental attributes obtained from Geographical Information System surveys and indicators of socioeconomic status and exposures for individuals. Overall prevalence of *Leptospira* antibodies was 15.4% (95% confidence interval [CI], 14.0–16.8). Households of subjects with *Leptospira* antibodies clustered in squatter areas at the bottom of valleys. The risk of acquiring *Leptospira*



# SPAR

- the Semantic Publishing and Referencing Ontologies



## An annotated reference list

Sort by:

1. United Nations Human Settlements Programme (2003) The challenge of slums: Global report on human settlements 2003. London: Earthscan Publications Ltd. [Link](#) (CiTO: *obtains background from, Report, Book, Online Document, not peer reviewed*)
2. Riley LW, Ko AI, Unger A, Reis MG (2007) Slum health: Diseases of neglected populations. BMC Int Health Hum Rights 7: 2. [DOI PubMed PubMedCentral](#) (CiTO: *obtains background from, shares authors with, Opinion, Journal Article, peer reviewed*)
3. Sclar ED, Garau P, Carolini G (2005) The 21st century health challenge of slums and cities. Lancet 365: 901–903. [DOI PubMed](#) (CiTO: *obtains background from, Opinion, Journal Article, peer reviewed*)

- The first three references from the reference list of our enhance version of Reis *et al.* (2008), with the citation typing display turned on

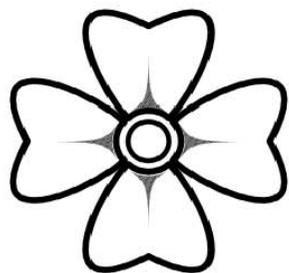


## CiTO and SPAR

- Spurred by the need to encode such citation metadata in machine-readable form, I first developed **CiTO, the Citation Typing Ontology**
- CiTO has now been modularized to separate its initial purposes of characterizing
  - the existence and nature of a bibliographic citation (**CiTO**)
  - the object of such a citation – i.e. the cited bibliographic object (**FaBiO**)
  - the number of citations received by that cited bibliographic object (**C40**)
- To these, five additional ontologies have been added
- The result is **SPAR, the Semantic Publishing and Referencing Ontologies**, an integrated suite of complementary ontologies to describe all aspects of semantic publishing and referencing, which is now available for use
- SPAR is described at <http://opencitations.wordpress.com/2010/10/14/introducing-the-semantic-publishing-and-referencing-spar-ontologies/>

# SPAR

Semantic  
Publishing

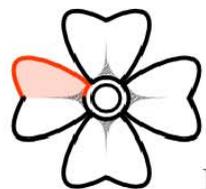


And  
Referencing



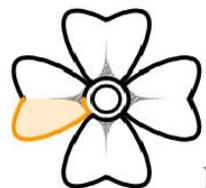
**FaBiO**

FRBR-Aligned Bibliographic Ontology



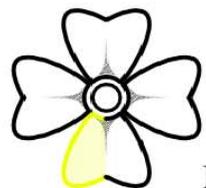
**PRO**

Publishing Roles Ontology



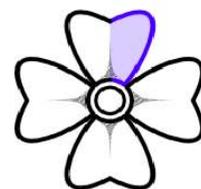
**PSO**

Publishing Status Ontology



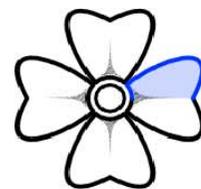
**PWO**

Publishing Workflow Ontology



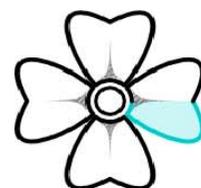
**CiTO**

Citation Typing Ontology



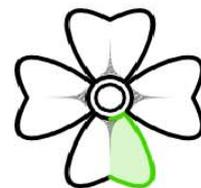
**BiRO**

Bibliographic Reference Ontology



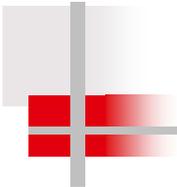
**C4O**

Citation Counting and  
Context Characterization Ontology



**DoCO**

Document Components Ontology



## Uses of CiTO, the citation typing ontology

- To permit the **existence of a citation** between a citing work and a cited work to be recorded in RDF

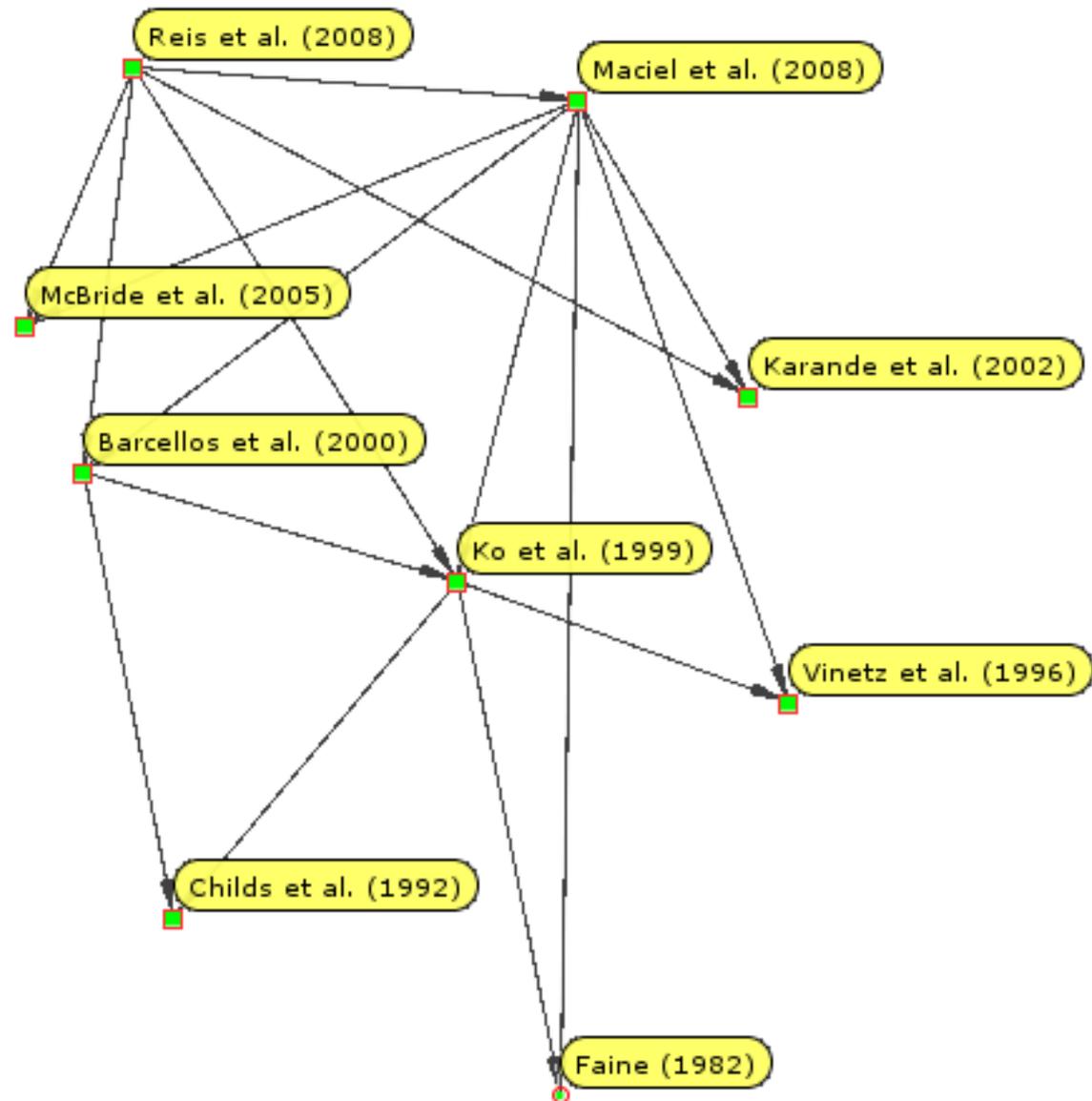
```
<http://example1.com/citingwork> cito:cites
```

```
<http://example2.com/citedwork> .
```

- Even this simple statement that a citation exists opens significant possibilities, for example in enabling the easy creation of **citation networks** simply by combining the RDF citation lists from several papers
- 
- To permit the **nature of the citation** between a citing work and a cited work to be characterized,
    - **both factually**
      - *reviews, sharesAuthorsWith, usesMethodIn*, etc
    - **and rhetorically**
      - *confirms, corrects, refutes*, etc

## A selected citation network from Reis *et al.* 2008

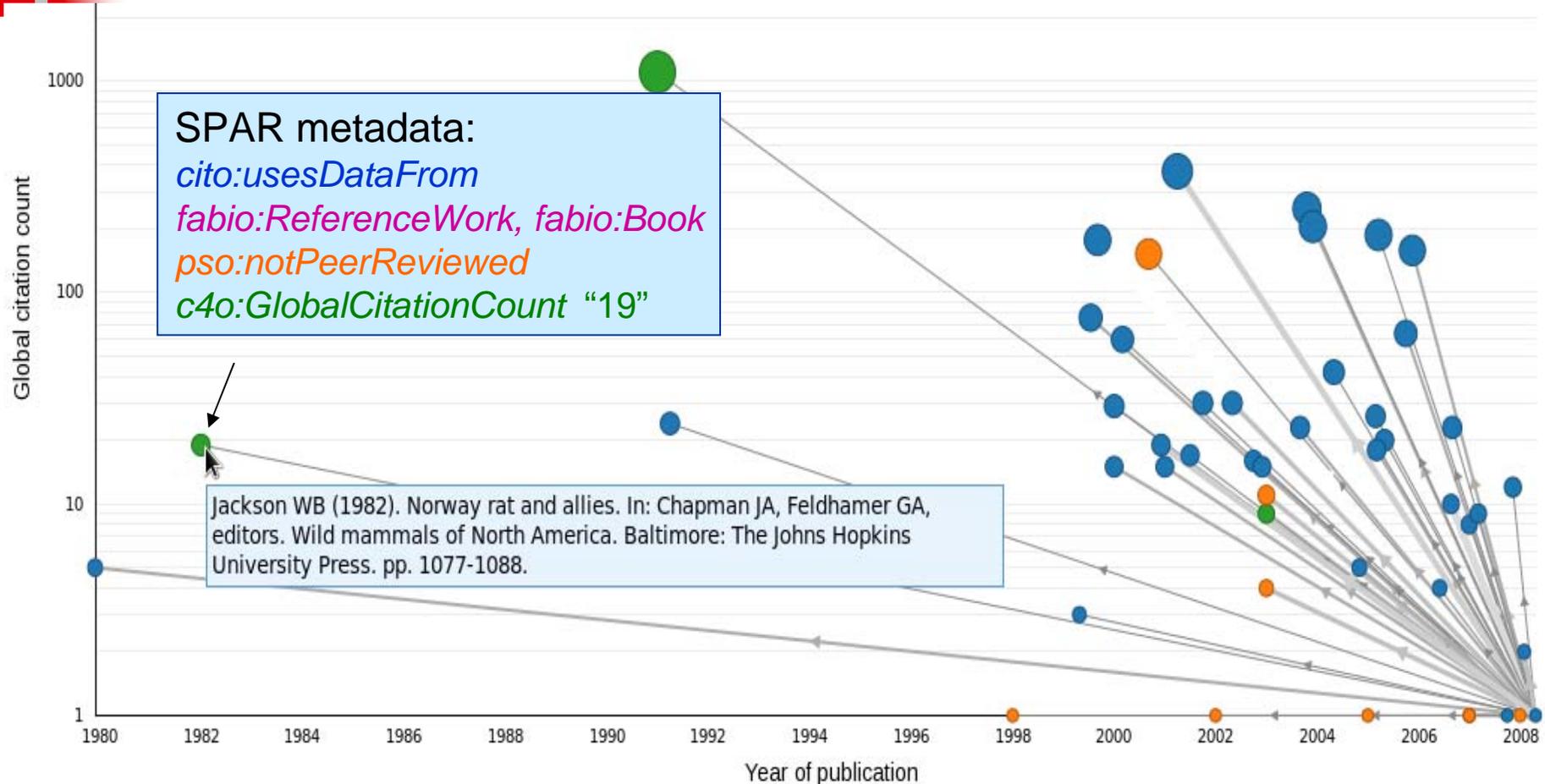
- This small demonstration network was constructed automatically, by integrating RDF citation data from Reis *et al.*, Maciel *et al.*, Barcellos *et al.* and Ko *et al.*, then visualized it using **Welkin**
- More extensive citation networks would reveal key papers, and enable navigation through the literature of a domain of knowledge, eg. on the 2005 SARS outbreak



# Uses of C4O and FaBiO

- C4O, the Citation Counting and Context Characterization Ontology, permits citation frequencies to be recorded
  - both local: e.g. “Paper A cites Paper B once, but cites Paper C ten times”
  - and global: e.g. “Paper C is cited 234 times according to Scopus”
- FaBiO, the FRBR-aligned Bibliographic ontology, permits characterization of the cited works themselves as journal articles, books, etc.
- FaBiO uses the FRBR entity model to make distinctions between
  - *Work* An abstract concept, e.g. your latest research paper
  - *Expression* A realization of that work, e.g. the submitted preprint
  - *Manifestation* An embodiment of that manifestation, e.g. as a PDF
- Examples of annotations using FaBiO
  - Sub-classes of *Work* include
    - Discussion*
    - ResearchPaper*
  - Sub-classes of *Expression* include
    - BlogPost*
    - JournalArticle*
  - Sub-classes of *Manifestation* include
    - Blog*
    - PrintObject*

# Citation display from Reis *et al.* using SPAR RDF metadata



- Here, using a plugin developed for the RDF visualization program Exhibit, references are displayed *on a temporal axis*, colour-coded to indicate **journal articles**, **reviews** and **books**, and with diameters and y-axis position determined by their global citation frequency as determined from Google Scholar



## Citations in Context

Recording the *contexts* of citations,  
and relevant statements in the cited article

as exemplified in our semantically enhanced  
version of Reis *et al.* 2008

## Nomenclature

- Typical lazy use of the word “reference”

The screenshot shows the top portion of a PLoS Neglected Tropical Diseases article. The journal logo and name are at the top, followed by the text "a peer-reviewed open-access journal published by the Public Library of Science". Below this is a green bar with "RESEARCH ARTICLE" on the left and "OPEN ACCESS" with a lock icon on the right. The article title is "Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums". The authors are "Renato B. Reis<sup>1\*</sup>, Guilherme S. Ribeiro<sup>1\*</sup>, Ridalva D. M. et al.". The citation information is "Citation: PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.000...". Below the citation is the section "DISCUSSION" with the text "Our findings confirm hypotheses raised by previous ecologic studies [6],[10],[11] that infrastructure deficiencies related to open sewers, flooding and open refuse deposits are transmission sources for leptospirosis in the slum environment." Below the discussion is the "REFERENCES" section with one entry: "6. Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, Riley LW (1999) Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820-825." Two callout boxes with pink borders and blue text point to the citation "[6],[10],[11]" and the reference entry, both labeled "a reference".

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a peer-reviewed open-access journal published by the Public Library of Science

RESEARCH ARTICLE OPEN ACCESS

### Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums

Renato B. Reis<sup>1\*</sup>, Guilherme S. Ribeiro<sup>1\*</sup>, Ridalva D. M. et al.

Citation: PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.000...

#### DISCUSSION

Our findings confirm hypotheses raised by previous ecologic studies [6],[10],[11] that infrastructure deficiencies related to open sewers, flooding and open refuse deposits are transmission sources for leptospirosis in the slum environment.

#### REFERENCES

6. Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, Riley LW (1999) Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820-825.

“a reference”

“a reference”

“a citation”

The screenshot shows the top portion of a Lancet article. The journal name "THE LANCET" is at the top. Below it is the issue information: "Volume 354, Issue 9181, 4 September 1999, Pages 820-825". The word "Article" is followed by the title "Urban epidemic of severe leptospirosis in Brazil". The authors are "Albert I Ko MD<sup>a, c,</sup>, Mitermayer Galvão Reis MD<sup>a</sup> et al.". A callout box with a pink border and blue text points to the title, labeled "a reference".

# THE LANCET

Volume 354, Issue 9181,  
4 September 1999,  
Pages 820-825

Article

## Urban epidemic of severe leptospirosis in Brazil

Albert I Ko MD<sup>a, c,</sup>, Mitermayer Galvão Reis MD<sup>a</sup> et al.

“a reference”

# Nomenclature

- Nomenclature adopted by the SPAR ontologies

The image shows a screenshot of a PLoS Neglected Tropical Diseases article. The article title is "Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums". The authors are Renato B. Reis and Guilherme S. R. The citation is "PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.000". The article is categorized as a "RESEARCH ARTICLE" and is available under "OPEN ACCESS".

Annotations on the screenshot include:

- A blue box labeled "Citing article" is positioned at the top right of the article page.
- A pink box labeled "c4o:InTextReferencePointer" points to the citation text.
- A green box labeled "c4o:denotes" points to the citation text.
- A pink box labeled "biro:BibliographicReference" points to the citation text.
- A green box labeled "biro:references" points to the "REFERENCES" section.
- A green box labeled "cito:cites" points to the citation text.
- A red box labeled "Cited article" is positioned at the bottom right, pointing to the article "Urban epidemic of severe leptospirosis in Brazil" in *The Lancet*.

The "Cited article" section shows the title "Urban epidemic of severe leptospirosis in Brazil" by Albert I Ko MD et al., published in *The Lancet*, Volume 354, Issue 9181, 4 September 1999, Pages 820-825.

## A typical bibliographic citation

- At some point in the text of the citing article, a citation is made to a paper [6], bibliographic details of which are given in the reference list
- However, the *reasons* for citing that particular paper are not explicit

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RESEARCH ARTICLE OPEN ACCESS

### Impact of Environment and Social Gradient on *Leptospira* Infection in Urban Slums

Renato B. Reis<sup>1#</sup>, Guilherme S. Ribeiro<sup>1#</sup>, Ridalva D. M. et al.

**Citation:** PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.0000228

#### DISCUSSION

Our findings confirm hypotheses raised by previous ecologic studies [6],[10],[11] that infrastructure deficiencies related to open sewers, flooding and open refuse deposits are transmission sources for leptospirosis in the slum environment.

#### REFERENCES

6. Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, Riley LW (1999) Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820-825.



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Citation: PLoS Negl Trop Dis 2(4): e228. 2008 doi:10.1371/journal.pntd.0000228

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### INTRODUCTION

**A** Urban epidemics of leptospirosis now occur in cities throughout the developing world during seasonal heavy rainfall and flooding [6], [11]–[18].

### DISCUSSION

**B** Our findings confirm hypotheses raised by previous ecologic studies [6],[10],[11] that infrastructure deficiencies related to open sewers, flooding and open refuse deposits are transmission sources for leptospirosis in the slum environment.

**C** In Salvador, leptospirosis is due to transmission of a single agent, *L. interrogans* serovar Copenhageni [6],[28].

### REFERENCES

6. Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, Riley LW (1999) Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820–825.

- Three of the ten in-text reference pointers to Reference [6], Ko *et al.*
- **A** is about rainfall and flooding
- **B** is about the environment
- **C** is about the infectious agent

## Article

### Urban epidemic of severe leptospirosis in Brazil

Albert I Ko MD<sup>a, c, ✉, ✉</sup>, Mitermayer Galvão Reis MD<sup>a</sup> et al.

#### Introduction

- 1 Leptospirosis is caused by spirochaetes belonging to the genus *Leptospira*.
- 2 The infection is acquired through contact with animal reservoirs or an environment contaminated by their urine, produces a wide range of clinical manifestations.
- 3 ... urban slums (favelas) where the lack of basic sanitation favours rodent-borne transmission of leptospirosis.

#### Results

- 4 Severe flooding occurred during the heaviest period of rainfall between April 21 and April 27. The largest number of cases per week (39) was reported 2 weeks after this event.

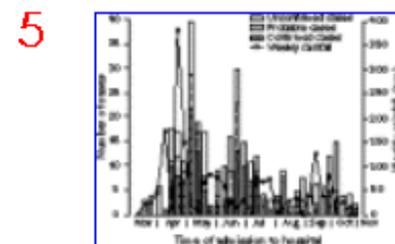


Figure 2. Weekly cases of leptospirosis and rainfall in Salvador, Brazil, between March 10, and Nov 2, 1996

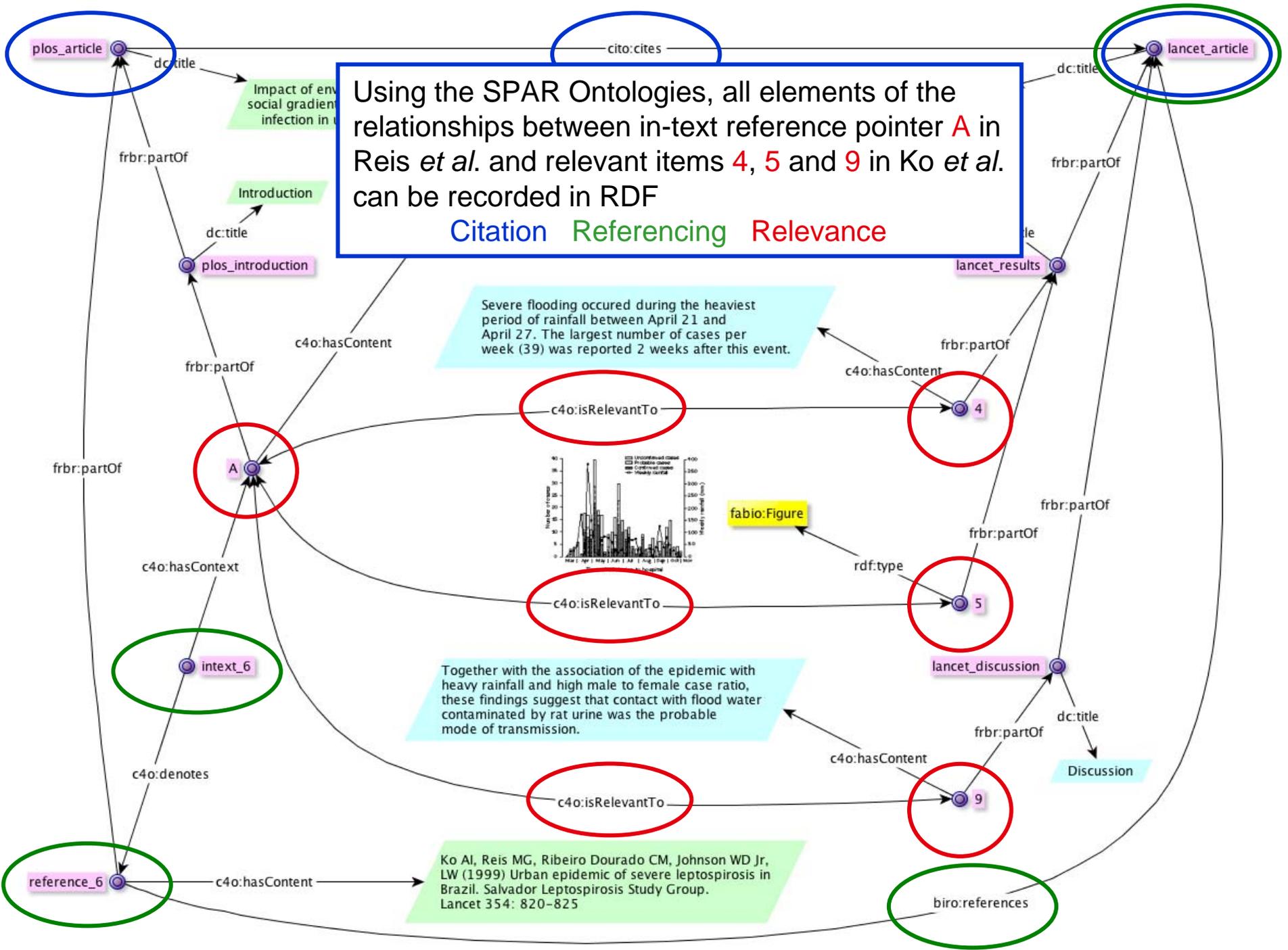
Real data !

- 6 All serogroup Icterohaemorrhagiae isolates were identified to be serovar *copenhageni*.

#### Discussion

- 7 Individuals at highest risk for severe leptospirosis were the urban poor living in the slums

- Six of nine statements in Ko *et al.* most relevant to those three in-text citation pointers in Reis *et al.*
- 4, 5 and 9 are relevant to A in Reis *et al.*
- 2, 3, 7 and 9 are relevant to B
- 1, 6 and 8 are relevant to C



Using the SPAR Ontologies, all elements of the relationships between in-text reference pointer **A** in Reis *et al.* and relevant items **4**, **5** and **9** in Ko *et al.* can be recorded in RDF

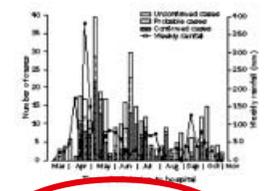
**Citation Referencing Relevance**

Severe flooding occurred during the heaviest period of rainfall between April 21 and April 27. The largest number of cases per week (39) was reported 2 weeks after this event.

c4o:isRelevantTo

c4o:isRelevantTo

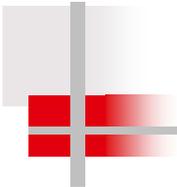
c4o:isRelevantTo



fabio:Figure

Together with the association of the epidemic with heavy rainfall and high male to female case ratio, these findings suggest that contact with flood water contaminated by rat urine was the probable mode of transmission.

Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, LW (1999) Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820-825



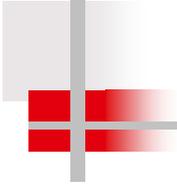
# The Open Citations Project

JISC

- publishing bibliographic citations as Linked Open Data

## Partners

- PLoS and Biomed Central (Open Access publishers)
- British Library (for UK Pubmed Central and DataCite DOIs)
- European Bioinformatics Institute (for UKPMC and CiteXplore)
- University of Cambridge: *Open Bibliography* sister project
- Open Knowledge Foundation's Bibliographic Working Group
- Bibliographic Knowledge Network: Will facilitate interoperability with related projects in the USA
- CrossRef
  
- We welcome involvement of others



## Open Citations Project objectives

- To establish [OpenCitations.net](http://OpenCitations.net), a public RDF triplestore for biomedical literature citations
- To harvest reference lists from journal articles, starting with
  - open access articles in [UK Pubmed Central](#)
  - articles published by [Public Library of Science](#) and [Biomed Central](#)
  - and by other publishers willing for [CrossRef](#) to release their citation data
  - articles from other open access repositories such as [EPrints](#)
- To convert these citation data into RDF using the SPAR ontologies, particularly CiTO, the Citation Typing Ontology
- To publish the reference lists from individual papers as separate Named Graphs, each identified by a Digital Object Identifier
- To publish these citation datasets as Linked Open Data on the [Talis Connected Commons Platform](#) under an open data license, in both human- and computer-readable formats

# An example of citation metadata in RDF

**<http://dx.doi.org/10.1371/journal.pntd.0000228>**

**cito:cites** **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** # Reference [6];

frbr:part [a biro:BibliographicReference;

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biro:references **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** ] ;

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**cito:usesDataFrom** **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** ;

**cito:confirms** **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** ;

**cito:extends** **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** ;

**cito:sharesAuthorsWith** **<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>** .

# Reference [6]

**<http://dx.doi.org/10.1016/S0140-6736(99)80012-9>**

**dcterms:bibliographicCitation** "Ko AI, Reis MG, Ribeiro Dourado CM, Johnson WD Jr, Riley LW (1999). Urban epidemic of severe leptospirosis in Brazil. Salvador Leptospirosis Study Group. Lancet 354: 820-825.";

**prism:publicationDate** "1999-09-04"^^xsd:date ;

**cito:isCitedBy** **<http://dx.doi.org/10.1371/journal.pntd.0000228>** ;

frbr:realizationOf [ a **fabio:ResearchPaper** ] ; # work

a **fabio:JournalArticle** ; # expression

psr:holds [a psr:StatusInTime ; **psr:withStatus psr:peer-reviewed** ] ;

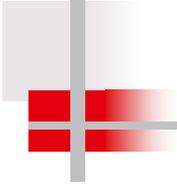
# Google Scholar on 11 March 2009: Cited 206 times.

**c4o:hasGlobalCitationFrequency** [ a **c4o:GlobalCitationCount** ;

**c4o:hasGlobalCountValue** "206"^^xsd:integer ;

**c4o:hasGlobalCountSource** **<http://scholar.google.com>** ;

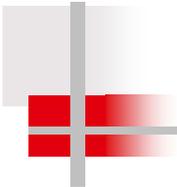
**c4o:hasGlobalCountDate** "2009-03-11"^^xsd:date ] .



## Benefits of incomplete citation data

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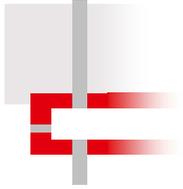
- With limited JISC funding, we cannot hope to “boil the whole ocean”. However, we hope to show the way and establish best practice
- While incomplete citation data is unsatisfactory, it is better than nothing! As with other Web 3.0 services, its value will improve as more data are submitted
- We intend complete coverage for certain journals (PLoS and BMC)
- Open Access articles cite papers of all types, including subscription access. Because of redundancy in citation, all key papers will be cited
- The overall topological structure of the citation network will be revealed, even with partial citation coverage
- We will create a ‘benchmark’ corpus of high-quality RDF citation data that machine learning/network analysis communities can use to develop tools



## Why participate in the Open Citations Project?

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- Once Open Citations has established procedures using open access journal articles from our core publishers, we will open Open Citations for contributions from other publishers
- Exposure of citation data as Linked Open Data will increase exposure of both the citing and cited articles, driving readers to publishers' sites
- We will demonstrate the benefits of citation data publication using click-through data to full-text articles
- Release of citation data at the time of publication will benefit subscription-access journals where the text is not open immediately
- Later release of citation data – after a six- or twelve-month embargo – will still be of value, although not as great as for immediate access
- **CrossRef** is keen to be involved in this, and provides a convenient mechanism for sharing the citation data of publishers who opt in



## In conclusion: data publishing and global warming

Waiting for some international committee in Copenhagen to create the perfect solution to the data publication problem is not the way forward

Just as we can each act locally to reduce our carbon footprint,

so too we can each do something personally  
**to increase our data footprint**

Each of us, whether researcher, publisher or government agency, can take responsibility for the open publication of our own research data, bibliographic data and citation data

**The important thing is to make a start !**





end