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The QMRA Wiki: A Social Media Tool for Interdisciplinary and Interagency Collaboration for Quantitative Microbial Risk Assessment

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Abstract: This study presents a web-based social media system that supports quantitative microbial risk assessment (QMRA) and collaboration among interdisciplinary scientists and interagency stakeholders, namely the QMRA wiki. The QMRA wiki is intended to aid the development of risk assessments by providing a collection of raw data, models and calculators as well as a platform for exchange and cross-fertilization between the QMRA community and its stakeholders. The wiki is organized around the exploration of the QMRA paradigm including the following five components: hazard identification, dose-response assessment, exposure assessment, risk characterization and risk management. Additionally, the wiki houses a number of case studies and a library of other resources and educational materials. Its underlying structure of QMRA knowledge and models is housed within a semantic structure that captures the content of each page and the relationships between pages. Relationships are based on pathogen type, specific organism, or modeling type. The objectives that underpin the QMRA wiki include the (1) Collection of raw data and fitted models; (2) Dose-response and exposure analysis through the use of calculators or apps; (3) Transparency of the scientific underpinnings of microbial risk assessment; (4) The education of future QMRA experts.

Keywords: Quantitative Microbial Risk, Wiki, Social Media Tool, Boundary Object, Modelling Tools

1   INTRODUCTION

1.1 Social Media and Wikis

Social media are Internet-based tools that allow users to easily create, edit, and/or link to content or to other creators of content (Kaplan & Haenlein, 2010). Popular social media technologies include blogs, microblogs, wikis, social networking sites, and video or other content sharing sites and communities. Wikis belong to a specific subclass of social media technologies that we describe as *collaborative projects* (Kaplan and Haenlein, 2010), and represent web-based applications that allow people to add, modify, or delete content through collaboration.

The Wiki concept was first introduced by Ward Cunningham in 1994 and displays the following characteristics: (1) Open (i.e., anyone can access or create content through a simple Web browser interface), (2) Enabling real-time editing, (3) Displaying evolving and dynamic content (i.e., the ongoing collaborative creation of content leads to an ever-changing information landscape), (4) Intuitive interface (i.e., easy-to-use), and (5) Networked text (i.e. page links allow for meaningful topic associations between pages).

1.2 Quantitative Microbial Risk Assessment

Quantitative microbial risk assessment (QMRA) represents a growing and promising field consisting of a formal process for estimating human health risks by addressing exposures to microbial pathogens and infectious disease processes – and accepted for its merits to recreational water safety (US EPA, 2011). QMRA is positioned at an interdisciplinary nexus requiring the deep expertise, cumulative knowledge, and extensive cross-fertilization of many disciplines including: microbiology, epidemiology,

environmental engineering and science, mathematics, communication, management, and sociology. Due to its quantitative nature the domain of QMRA aims to bridge the gap between; scientists, policy-makers, and the general public in enhancing the effectiveness and efficiency with which scientific results are translated into actionable policies and practical safety measures.

1.3 The QMRA Wiki

Support for the development of the interdisciplinary field of QMRA was promoted by the Centre for Advancing Microbial Risk Assessment (CAMRA), a jointly funded US EPA and DHS Centre of Excellence from 2005 to 2013. CAMRA achieved two missions: (1) development of models, tools, and information that could be used in a credible risk assessment framework to reduce or eliminate health impacts from biological agents of concern in the indoor and outdoor environment; and (2) building a national network for microbial risk knowledge management, learning, and transfer, for the community of scientists and students via educational programs and a community of professionals in the field and in our communities. In order to address these two missions, an online system for sharing knowledge and models within the QMRA global community was developed in the form of the QMRA wiki.

The first stages of the QMRA wiki were housed in a standard MySQL database that an implementation of the MediaWiki (http://www.mediawiki.org/) package. This first implementation of the wiki served as the proof of concept and the development of the initial database that would serve as the foundation for the current QMRA wiki. Now the QMRA wiki belongs to the class of wikis called *semantic wikis* where, rather than using structured text and untyped hyperlinks, the relationships between pages and information about the data stored within each page is captured in an exportable database, that still uses the underlying MySQL database from the MediaWiki implementation. The objectives of the QMRA wiki include the (1) collection of raw data and fitted models; (2) the enabling of dose-response, persistence and exposure analyses through the use of calculators or apps (JAVA applications or **R** code implementations); (3) enhanced transparency of the scientific underpinnings of microbial risk assessment; (4) and the education of future QMRA experts, policy-makers, and the general public.

In what follows, we will describe in detail the following two core components of the QMRA wiki:
- (I) Explore the Risk Framework—The first and primary component of the wiki, which serves as a knowledge repository is further broken out into the five areas of the risk paradigm: hazard identification, dose-response, exposure assessment, risk characterization and risk management.
- (II) QMRA tools—The second component of the wiki that includes Apps and Calculators; Case Studies and the QMRA Library.
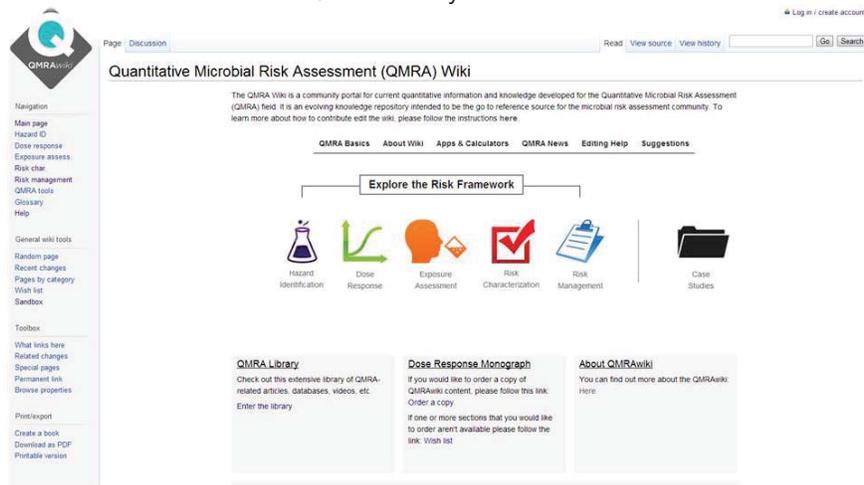

Figure 1. QMRA Wiki Main Page Providing Links to the Key Components of a QMRA

2   EXPLORE THE RISK FRAMEWORK

2.1 Hazard Identification

The hazard identification section provides a general overview highlighting the quantitative data that should be collected to characterize a pathogen's hazard; a summary table of agents organized by microbial group; and links to important outbreaks (Figure 2). Within the summary table, case fatality rates, burdens of disease and incubation times for a number of microorganisms are summarized.
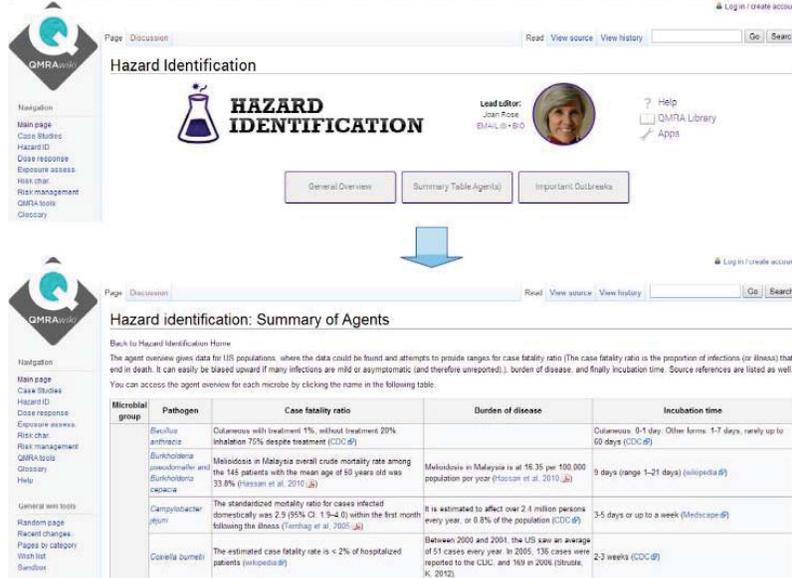

Figure 2. Hazard Identification Page

2.2   Dose-Response Assessment

The dose-response section of the QMRAwiki (Figure 3) consists of a comprehensive collection of information on, models, parameter estimates and raw data for the dose-response relationship. A detailed explanation of the most widely used dose-response models and the mathematical and statistical approaches for fitting these models is provided as background. An extensive collection of fitted models for bacteria, viruses, protozoa, and prions is provided summarizing experimental details and providing best fit parameters, LD50 and ID50 values for historic data sets.
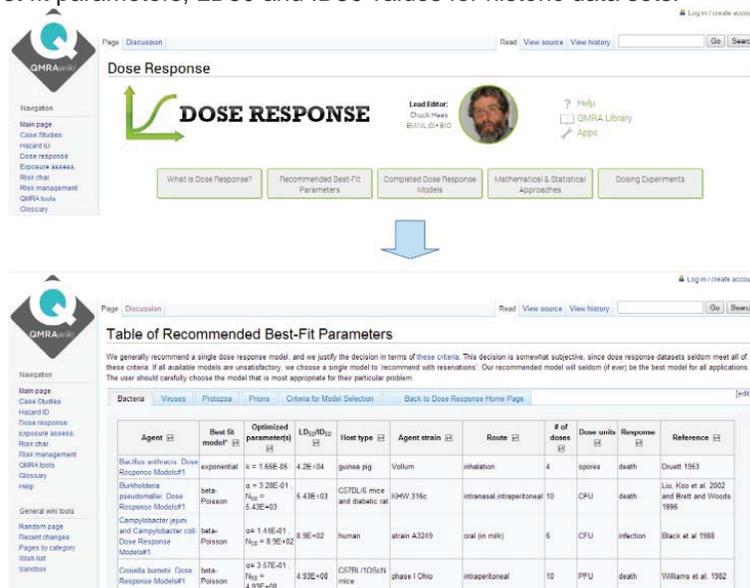

Figure 3. Dose-Response Assessment

2.3   Exposure Assessment

The exposure assessment page (Figure 4) is designed to house a number of pathogen specific and general exposure parameters to be used for the quantitative exposure analysis. This portion of the QMRA paradigm typically utilizes a large range of data and information, a much abbreviated example list is: occurrence, persistence, excretion and survival rates, and fate and transport data and models for the pathogens in various environmental media. An overview of microbial persistence and inactivation models is also provided. This section will be expanded to include optimized models of varying complexity for multiple environmental media, analogous to the format used for the dose response assessment section.
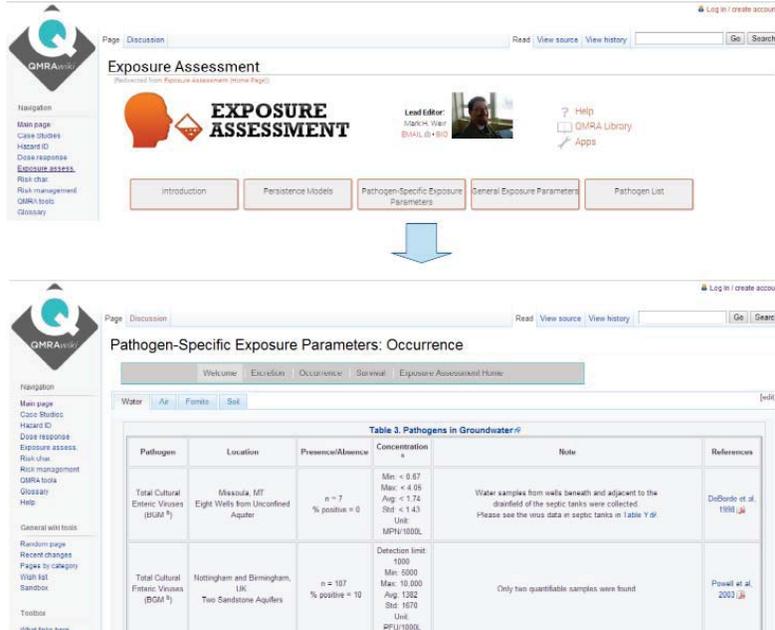

Figure 4. Exposure Assessment

2.4   Risk Characterization

The Risk Characterization section (Figure 5) provides explanation and tutorials to assist with the mathematical integration of the dose-response and exposure assessment analysis to generate estimates of risk. A cornerstone of the educational portion of the QMRA wiki, the Risk Characterization section informs the user of how to approach and build their own models, as well as demonstrate successful attempts through the tutorials. The case studies section is an important link to this section as well, demonstrating the risk characterization in a broader and applied context.
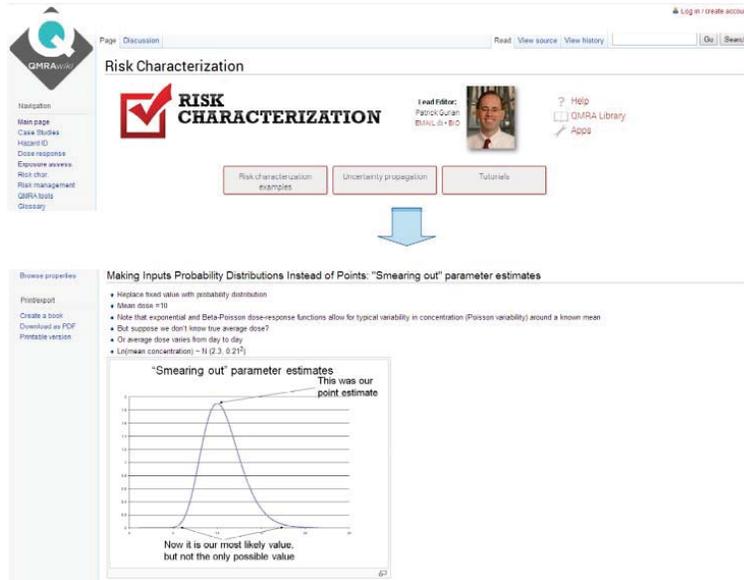
Figure 5. Risk Characterization

2.5 Risk Management

Finally, the Risk Management (Figure 6) section of the wiki includes a discussion of quantitative methods of analysis, such as cost benefit and decision analysis, along with examples. It also includes a description of the social science topics related to risk such as perception and communication. In later versions, we will compile a set of parameter values under control measures organized by environmental media type to assist in the evaluation of risk management strategies.
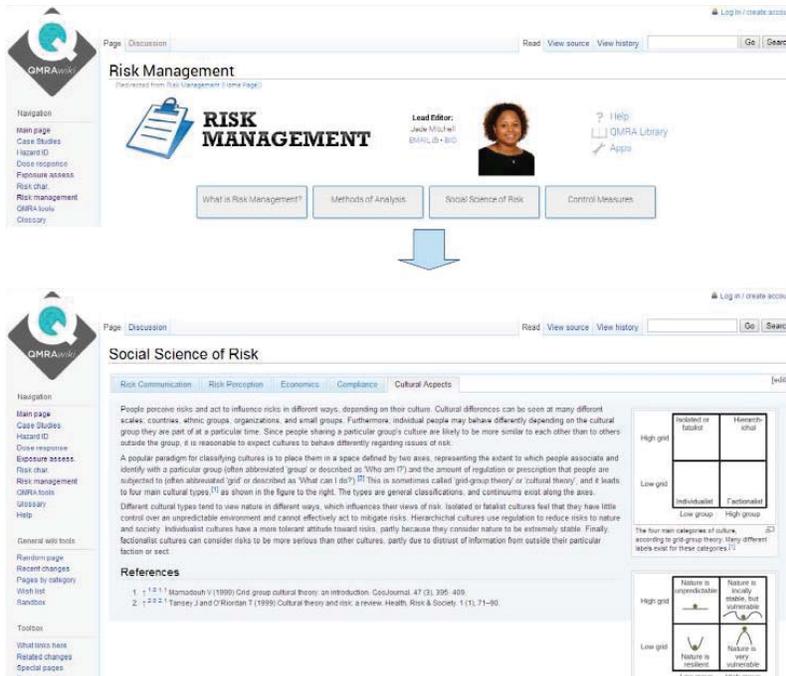

Figure 6. Risk Management Page

3. QMRA RESOURCES

The first QMRA resource that is provided through the wiki includes various QMRA tools, referred to Apps and Calculators. The Apps and Calculators page contains a set of newly developed tools for analyses and well as links to other developed model to assist risk assessors.

The second QMRA resource includes Case Studies. These are based on previous short-courses taught through the Centre for Advancing Microbial Risk Assessment. These studies are summarized by topic and describe the data and models used to generate risk estimates and can be employed for training and educational purposes, of both QMRA scientists as well as other stakeholders.

Finally, a QMRA Library houses educational materials, links to scholarly articles and databases related to microbial risk assessment.
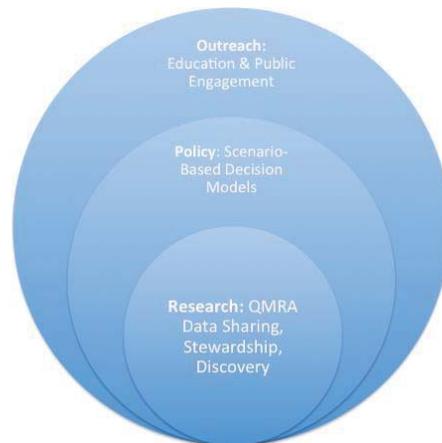
4   DISCUSSION: THE QMRA WIKI AS A BOUNDARY OBJECT

4.1 Boundary Object

The QMRA wiki is currently being redesigned in order to extend its value as a resource for scientists and for the education of students in the QMRA domain in becoming an interdisciplinary and interagency nexus that serves three groups of stakeholders; scientists, policy-makers, and the general public.

In order to guide the redesign of the wiki platform, we draw on the concept of a boundary object. Boundary objects, introduced by Star & Griesemer (1989), refer to artifacts that "are plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star 1989: 393). Thus boundary objects are artifacts that can be leveraged by multiple groups of stakeholders and help them establish a joint field for interaction, collaboration, leading to joint problem-solving despite the epistemic (*i.e.*, technological, social, and professional) and evidential (*i.e.*, geographic and cultural) boundaries that separate them.

The boundary object metaphor has resulted in the following conceptual framework (Figure 7) that will guide the redesign and –development of the wiki. Furthermore, the benefits for the three aforementioned stakeholder groups associated with redesigning the wiki as a boundary object are outlined in Table 1 below.

Figure 7. A Conceptual Model for the Boundary Object QMRA Wiki Redesign

5   CONCLUSION

In its current form, the QMRA wiki aims to enhance scientific collaboration and discovery in the domain of QMRA through offering a central knowledge repository where scientists from diverse disciplinary and geographic backgrounds can access data, models, and instruments pertaining to hazard identification,

dose-response, exposure assessment, risk characterization, and risk management as well as a set of Apps and Calculators, Case Studies, and other written resources through the QMRA Library.

The field of QMRA is resource intensive, technically demanding and has suffered from credibility issues (Silbergeld, 1993; Montague, 2004; Michaels 2008). Recent decades of biodefense concerns and numerous foodborne disease outbreaks have heightened the need for immediate and actionable knowledge that can be accessed by policy-makers and the general public. Therefore, use of the QMRA wiki format as an effective tool for scientific knowledge dissemination across policy networks and public channels may offer advantages for developing risk assessments. The accessibility of the web-based platform also increases transparency and the ability for the direct involvement of external stakeholders (*e.g.*, policy makers and the general public), that allows for public engagement in science. Consequently, in its future form, the QMRA wiki will be redesigned as a boundary object, serving as a nexus for bringing together three stakeholders, namely scientists, policy-makers, and the general public. Thus not only enhancing data integrity, access, stewardship or scientific discovery and collaboration, but also offering opportunities for enhancing the efficiency and effectiveness of policy- and decision-making, risk management, education, and public awareness in the QMRA domain.

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Table 1. The Benefits of the QMRA Wiki for Three User Groups

	QMRA Scientists	Policy-Makers	General Public
Benefits of QMRA Wiki:	*Integrity:* Enhances the quality of data and instruments through open access, real-time editing, and the enabling of constructive criticisms and dialogues	*Integrity:* Enhances the quality of policy decisions, primarily in terms of their national and global impact, by providing an easy-access and free scientific foundation	*Integrity:* Enhances the quality of education by promoting experiential learning (the active engagement of learners in knowledge production)
	Access: Enables data and instrument sharing through a central knowledge repository	*Access:* Offers immediate and actionable knowledge that can drive novel policy- and decision-making	*Access:* Represents a free-access information repository that can support the education of a new generation of QMRA scientists
	Stewardship: Supports the reuse of data and instruments thereby further enhancing the reliability of existing models	*Stewardship:* Enables re-use of successful policies by enabling direct dialogues between policy-makers from different microbial risk domains or geographic locations	*Stewardship:* Facilitates accurate, instant, and real-time risk information and updates on environmental risks (e.g., maps, environmental issue profiles) for enhancing public awareness of microbial risks
	Scientific Discovery: Improves the speed and accuracy of scientific discovery through enhancing data richness	*Data-Based Decision-Making and Risk Assessment:* Provides intuitive plug-in applications that enables fast and data-driven decisions and risk assessments	*Community Decision-Making and Problem Solving:* Intuitive and real-time data access can help to support the safety and response readiness of local communities
	Scientific Collaboration: Establishes an integration platform for bringing together scientists from diverse disciplines and geographic locations	*Science-Policy Collaborations:* Facilitates dialogues between scientists and policy-makers to enhance the relevance of academic research while simultaneously improving the credibility of policy-making	*Science-Public Collaboration:* Creates opportunities for "citizen science" thereby enhancing public engagement and support for QMRA research