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Research infrastructures, policies and the ‘web of prevention’: the ethical implications of inadequate research environments

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Abstract

The dual-use potential of scientific research refers to the possibility that any beneficial scientific research may be misused for nefarious purposes by a third party. This potential within the life sciences has led to much discussion regarding ways to raise awareness and limit possible harm. The concept of a ‘web of prevention’ as a multifaceted system for addressing this potential for harm provides a comprehensive method of conceptualizing a system of controls in the life sciences. The web of prevention involves multiple stakeholders, from diverse backgrounds such as science, public health, security studies and governance. Research within the life sciences relies on a number of different structures, such as waste disposal and border controls, which provide a comprehensive environment for scientists to work in. The web of prevention relies on the assumption of these systems working to support any further initiatives that are proposed. Unfortunately, in many countries around the world, these systems are insufficiently addressed, which may raise ethical problems. Structural problems may undermine the web of prevention and alter the responsibilities attributed to the individual scientist within this system. Examples from sub-Saharan Africa illustrate two pertinent structural difficulties, and these are discussed in relation to ethical responsibilities.

Keywords

dual-use; biosecurity; biosafety; laboratory; ethics; responsibility; international security

The web of prevention

Developments in the life sciences during the early twenty-first century have yielded impressive advances in the fields of medicine and agriculture (US Department of Agriculture 2003, Weatherall 2006) amongst others, with concurrent rapid developments in the field of information technology resulting in innovative data storage, sharing and manipulation, allowing data to be used in previously unimagined ways. With great

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knowledge, however, comes great responsibility, and there are increasing concerns that these same advances may increase the dangers of misuse. This double potential of research has come to be termed 'dual-use'. Although traditionally a term used to refer to technologies with both civilian and military applications, it is evolving to now refer to the potential for any emerging knowledge or technique with beneficial applications to be misused for nefarious purposes (Rappert 2007).

The rise of life science research around the globe, as well as the ease and frequency with which data and materials are shared between laboratories, highlights the need to improve global security standards and international cooperation when addressing the challenges of dual use. In particular, the events of 2001 have resulted in considerable concern regarding the misuse of the life sciences, and legal, scientific, security, public health and law enforcement experts from around the world have worked together to explore ways of improving coordination and cooperation to increase security, without limiting the research necessary for the progression of scientific research (Rappert 2007, p. xiiv). Currently, however, attempts to address dual-use issues at the international level are complicated, and attempts to standardize biosafety, biosecurity and best practices require further attention (Rappert 2007, p. xiiv).

Examining the 'web of prevention'

Dual-use risk management at national and international levels requires a multifaceted approach of oversight involving science, security and educational components (Feakes *et al.* 2007, Rappert 2007). This is based on the assumption that there is no single solution to the dual use challenges in the life sciences, and that scientific research would not flourish under one overarching initiative. The concept of a web of prevention has had currency in discussions on dual-use debates since the early 1990s and has been endorsed by the UK (initially by Graham Pearson, then the Director-General of the Chemical and Biological Defence Establishment at Porton-Down in the UK), the USA (in reports such as NSABB 2006) and many other countries. Aspects of the web of prevention include the following:

- Export controls.
- Disease detection and prevention.
- Effective threat intelligence.
- International and national prohibitions.
- Biosafety and biosecurity.
- Oversight of research (as described by the Bradford online educational module resource).

While the web of prevention is an eminently practical way of visualizing dual-use risk management at national and international levels, it is not without its problems. In addition to differences in national priorities that may be reflected in implementation variations, the formation of a functioning, effective web of prevention presupposes investments – financial and otherwise – in both the structure of scientific research and its related institutions.

Structural requirements for a functioning system of prevention

When considering the web of prevention it is important to not only address the initiatives being proposed, but also the infrastructures upon which they are imposed, both within and beyond the laboratory. This includes the infrastructure of the laboratory itself, the operating research culture, and extra-laboratory systems such as local-level waste disposal and national-level border controls. Many of these infrastructures are managed through biosafety and biosecurity regulations; however, these are not internationally standardized and vary considerably. Discussions around the structural requirements of a functioning web of prevention are less often addressed, and there is an erroneous tendency towards the assumption of a homogenous scientific infrastructure underpinning international dual-use efforts.

During fieldwork conducted in laboratories in sub-Saharan Africa, interviews were held with life scientists during which they were invited to comment on the infrastructural challenges that they experienced in their daily work. Issues such as funding structures, mentorship and supervision, waste disposal, import and export controls, as well as ethical surveillance in the form of research ethics committees were commonly mentioned, consistent with findings from similar studies (Fine 2007). From these interviews, it was obvious that the assumption of an ethically coherent environment for research was misguided, which has serious implications for the web of prevention. Not only would failure in one of these underlying structures have the potential to create an environment with an increased capacity for harm – be it through health issues resulting from poor waste disposal, or the unwillingness to whistle-blow through poor laboratory culture – but it is apparent that lack of attention to these issues may have implications for ethics pedagogy, dual-use awareness-raising and recognition of ethical responsibilities among stakeholders.

Ethics education for dual-use issues

Within the web of prevention one of the most discussed areas is that of ethics education amongst scientists as a means to create a ‘culture of awareness and responsibility’ (NSABB 2006). Ethics pedagogy within the life sciences is a highly debated topic (Rappert 2010), and considerable debate continues regarding the style and content of education. For many scientists in sub-Saharan Africa, interaction with ethics is limited to online educational modules, such as that promoted by the NIH for their fundees. Specific modules such as those developed by the University of Bradford in the UK can also provide the tools for improving dual-use education on the continent (Bradford Disarmament Research Centre 2010). While these modules provide an important resource for developing capacity in ethics awareness, they are limited to providing the students with an introduction to ethical approaches, and laboratory culture does not usually support further education in this field.

One of the most important aspects of educating scientists regarding dual-use issues is the notion of responsibility. In the next section some current research on individual scientists’ responsibilities will be briefly examined. As these responsibilities assume structurally coherent backgrounds for research, I then discuss two issues arising from the fieldwork: waste disposal and border controls, examining these critically in terms of their influence on scientists’ responsibilities or their application. In particular, the next section focuses on how

these illustrated infrastructural problems may prove counter-productive in developing awareness of dual-use issues.

Responsibilities of the scientist in the web of prevention

There has been considerable debate regarding the preferred manner in which decision-making responsibilities in dual-use dilemmas should be apportioned (Miller and Selgelid 2007). The following section focuses on some of the ways in which individual scientists' responsibilities within the web of prevention have been conceptualized. These formulations of responsibility have been influential in the development of pedagogical tools, and understanding their strengths and limitations are an important part of developing ethics awareness.

Responsibilities of the individual scientist in the 'web of prevention'

The uncertain potential of any nefarious research activities, combined with the potentially diffuse nature of the beneficial inputs (McLeish and Nightingale 2007), makes it impossible for any one individual to take sole responsibility for the dual-use potential inherent in life science activities. Further, the increasingly global nature of modern life science research complicates attempts to apportion responsibilities. Nonetheless, scientists cannot be considered exempt from any responsibility at all. Discussions about individual responsibilities have to take into account not only the tension between the beneficial outcomes of the research and risk of deliberate misuse, but the limitations of the individual scientist in managing it.

Debates on ethics in the dual-use debate rely heavily on notions of responsibility and precaution, which are premised on the twin duties of doing no harm and doing good (Kuhlau *et al.* 2008, 2009). Thus, the individual responsibilities of scientists around dual-use issues can be divided into prospective responsibilities based on their duty of care, and retrospective responsibilities based on their involvement with a certain action (Ehni 2008). The duty towards beneficence highlights not only the aim to do good that should arguably underpin scientific research, but also that the freedom to carry out scientific research comes with accountability for the consequences of the research. This diffuse responsibility of scientists towards their work is similar to the global responsibility promoted by Hans Jonas, Emmanuel Levinas and Hannah Arendt (Arendt 1963, Jonas 1984, Levinas 1961). However, while the duty towards beneficence and non-maleficence can play a valuable role in motivating scientists, an unclear, indirect responsibility for dual-use issues might not be sufficient incentive for involving scientists in the dual-use debate.

In 2008 Kuhlau *et al.* addressed this issue, proposing a number of preventive moral obligations that should be adopted by the research community. Importantly, they suggested that scientists should not be required to estimate the probability and magnitude of misuse, reasoning that this is beyond the scope of the individual researcher's capacity and therefore an untenable obligation (Kuhlau *et al.* 2008). Instead they devised five criteria of responsibility for identifying harm:

- Responsibility is determined by the social role or position.

- Responsibility must be within that person's professional capacity and ability to enact.
- The harmful consequences must be reasonably foreseeable.
- The benefits of a research project should be weighed against the risks.
- Results should not be reasonably achieved through other means.

They also stated that:

... although bioterrorism is perceived by many as an imminent threat, it is not a reasonable obligation for life scientists either to prevent or respond to it. Responsibility, therefore, does not involve preventing the act of misuse but rather involves obligations concerned with preventing foreseeable and highly probable harm. (Kuhlau *et al.* 2008, p. 487)

A number of obligations required of scientists in line with their responsibilities were also suggested. These include the duties to prevent bioterrorism through the ethical conduct of research, to engage in response activities, to consider the negative implications of research, the duty to report activities of concern, to protect sensitive information and to oversee access to dangerous materials.

The concept of responsibilities with limitations is supported by the web of prevention. Within this model the scientist cannot only attend to personal responsibilities, but is absolved from further obligations by their apportioning throughout the system to the various stakeholders. A strong web of prevention thus supports the individuals within it by allowing them to potentially abdicate certain responsibilities to other actors within the system. However, as discussed above, it is important to note that this system is not limited to the dual-use initiatives explicit within the web, but also the implicit infrastructural support underpinning any research.

Thus, for the individual scientist, the responsibilities discussed above can only be said to be sufficient in a system in which the additional responsibilities are assumed by other actors in the web of prevention and the effectiveness of the structures supporting it. Thus, if the environment is not up to standard, it is important to question whether the responsibilities of the scientist discussed above should remain constant. Furthermore, if the environment is inadequate, does this undermine ethical instruction and the formation of a culture of ethics and awareness?

Pulling at the strings of the web

In most laboratories around the world, the quality and commitment of scientists are without reproach. Even in environmental terms, a lack of cutting-edge equipment does not necessarily imply safety or security risks and many laboratories routinely produce peer-reviewed research on limited budgets. However, despite the quality of work coming out of the laboratory and scientists' good intentions, the environment in which research is conducted may still present ethical problems through insufficiencies in structural support and the absence of (or inefficient) infrastructure.

During the fieldwork discussed here, it became increasingly apparent that the manner in which scientists discussed structural issues, both tangible and intangible, and the connections they made between the concepts of dual-use, responsibility, beneficence and non-maleficence were intimately connected to the environment in which they were working. In particular, when discussing the limits of responsibility in dual-use issues, scientists repeatedly connected their responsibilities to perceived deficiencies in their environment. Two issues commonly raised in these discussions are expanded on below.

Gaps in the web: waste disposal—Waste disposal according to internationally recognized standards (e.g., WHO 2009) is a prerequisite for research, upholding the principles of biosafety and biosecurity. In many countries laboratory waste is collected and disposed of by private companies which should be regulated and monitored by the government. Within the laboratory the responsibilities of individual scientists are limited to waste sorting (processing, sterilizing or neutralizing of materials prior to disposal, as well as correct sorting and bagging), and few interact with the waste disposal company apart from the laboratory manager.

While adequate waste disposal is not directly the scientist's responsibility (or perhaps it should be?), it should be shared with the private company and the government regulating body, because inadequate waste disposal places the scientist in a dubious position, undermining the ethical integrity of the research. While research within the confines of the laboratory may be beneficial and conducted by scientists with good intentions, the products of their research, when associated with ineffective waste disposal techniques, have a very real potential to cause harm.

This, in turn, directly challenges the beneficence of the work and the scientist's duty towards non-maleficence. Similarly, it potentially undermines the premises of responsibility and precaution at the centre of the dual-use debate. This raises two interesting issues: firstly, how far can one extend the duty of beneficence of the individual scientist and can ignorance be used as an excuse? How far do the responsibilities of the scientist extend towards the structures and infrastructures within which they conduct their research? Secondly, how does a situation such as this affect ethics teaching and awareness-raising? If scientists are challenged with principles such as responsibility and precaution whilst knowing of situations such as these, it places them in an ethically untenable situation.

From this brief example a number of issues are raised, the most important being the need to question what structures and infrastructures are being implicitly assumed to be ethically sound within the web of prevention. Further, it raises the question of whether deviations from the assumed norm could raise obstacles to the establishment and perpetuation of a culture of ethical awareness amongst scientists.

Pulling the web out of shape: export controls—Modern science is an international undertaking, and laboratories often utilize reagents, machinery, samples and data from around the globe. Efficient research requires a functioning system for the exchange of products between laboratories, commercial companies and repositories, all of which should be subject to regulations controlling export and import across national borders. Since the US

Anthrax attacks in 2001, the regulation of life science-related materials has become a heavily scrutinized area, leading to an increase in regulations governing the movement of materials across national borders (van Aken 2006, van Aken *et al.* 2004). In addition to increased stringency of existing regulations, new regimes have included registration of customers and the introduction of additional certification (Barletta *et al.* 2002, McLeish and Nightingale 2007). The impact of changing security laws has the potential to influence scientists worldwide, potentially causing disruptions to their work (van Aken *et al.* 2004) as they and their institutions struggle to adapt to the new regulations.

In order to have an effective system of scrutiny for the movement of materials it is insufficient for governments simply to draft legislation. The education of those who enforce legislation is also required. Globally, the commitment to developing border controls varies, as does the extent of education provision for customs officials (CPGGH 2006, Kirigia 2006). Increasingly complicated legislation therefore runs the risk of being enforced by individuals that have had inadequate training in the minutiae of life science research, which could undermine any legislative progress that could be claimed. This has the potential to manifest itself in many ways that counteract the integrity of science, such as delays in shipping, unnecessary holding of materials, incorrect storage of materials, and refusal to allow materials with multiple purposes through.

For scientists routinely faced with these challenges, the absence of adequately comprehensive import and export regulations places an unreasonable burden on them and their institutions, as the onus is on them to fulfil safety and security requirements requested by the other parties. This could potentially lead scientists to seek alternative routes, undermining the web of prevention. Furthermore, imbalanced increases in export and import regulations place considerable strain on scientists as they are faced with delays and disruptions. The over-representation of certain aspects of the web of prevention in daily research and the negative connotations that these engender could undermine the support of scientists for such control initiatives.

Supporting the scientist: gaps in the web

‘Picking up the slack’

Situations that put scientists in ethically dubious situations require further analysis within the web of prevention, and it is important that contingent influences on scientific research be recognized as potential contributors towards the integrity of the web. This is particularly important when one considers the development of an ethical culture of dual-use awareness in the scientific community.

In the example of waste disposal it was noted that a scientist embedded in an environment which routinely undermines any existing ethical teaching may face difficulties in adopting a culture of ethics and responsibility. This has been termed ‘ethical erosion’. This concept was introduced in medical ethics to describe situations which undermined the existing ethical standards of medical students by forcing them to acquiesce (consciously or unconsciously) to situations which undermine or counter their ethical values and training (Feudtner *et al.* 1994, Hundert *et al.* 1996, Crandall and Schaller 2004). This contributes to a loss of, or

failure to develop, an appropriate professional identity. The behaviour or conditions undermining students' ethical values and teaching in the medical context was termed a 'hidden curriculum', meaning an implicit set of values promoted by the structures and infrastructures within which medicine is taught and practiced.

The presence of a 'hidden curriculum' in medicine forces one to question the presence of similar situation in the sciences. This is especially important when one considers the varied (or often absent) level of ethical instruction of scientists and the implied, rather than explicit, set of ethical norms. While this is problematic for all pedagogical styles, this observation is particular pertinent to online ethics training, where the norms introduced in these modules may clash with those promoted in laboratories.

Furthermore, in a similar manner to that mentioned by Christakis and Feudtner (1993) in their studies of ethical education for medical students, much of the ethical training received by scientists is often skewed towards larger decisions potentially made in the future, ignoring the more subtle ethical decisions that are made on a daily basis. In many cases, particularly with students and technicians, the impact of ethics education is lessened by its lack of connection to the physical reality of the laboratory. This is an important consideration when one considers issues such as the waste disposal example, as technicians (a group poorly represented in many debates on science) are the staff who interact most regularly with the underlying infrastructure of scientific research, and are therefore in a vulnerable position with regards to such issues. Interestingly, however, this group of science practitioners are rarely the focus of ethical attention, and an increased awareness of their role in the scientific process may constructively address certain structural problems.

It is therefore important that three questions be raised in relation to the web of prevention. Firstly, are there structural issues – especially those which are often taken for granted and not regularly discussed – which undermine the ethical development of scientists? Secondly, by skewing the focus of ethics education towards the bigger issues relating to dual-use, are scientists being provided with the tools to deal with more basic, everyday situations which place them in ethically dubious positions? Thirdly, are the systems upon which scientific research is dependent placing scientists in positions where they are required to conduct an 'ethical balance sheet' to determine which principles to uphold?

Unfair expectations?

It is possible that there may be an imbalanced representation of the web in practice in the daily lives of scientists. Over-expression of one area of control could mean that attention is diverted from others, which could detract from the expression of the web as a complex and interdependent model of security. Legal responsibilities may be prioritized at the expense of ethical principles, for example. This bias in the exposure of scientists to the functioning of the web could undermine attempts to build support within those science communities operating in 'inadequate' environments.

Secondly, the unbalanced application of protective measures between countries can cause considerable problems for scientists working in unsupportive environments and can impede their work. It is, unfortunately, possible that such circumstances may result in scientists

circumventing the bureaucracy which is causing the problems, thus undermining the entire system.

A third consideration is dependent on the principle of precaution which is fundamental to the dual-use debate. In the absence of expected regulations and systemic support in one country, and in the face of increasingly stringent requirements from another, scientists and institutions in the 'weaker' country could be said to bear an unfair ethical responsibility, as the onus rests with them to control these additional aspects of their research as much as they can. Such activities may, of course, be beyond their powers to manage.

Raising awareness of structural/infrastructural issues

The web of prevention is a valuable way of conceptualizing the multi-stakeholder approach necessary for addressing the dual-use potential of the life sciences. It not only provides a comprehensive method of designating responsibilities and areas of concern between the various stakeholders, but also provides an adaptable framework which can be applied to many different environments.

One area of the web debate which is less commonly addressed is that of the structural prerequisites necessary to support the implementation of any dual-use initiatives. These include laboratory infrastructure and culture as well as extra-laboratory (infra)structures such as waste disposal and border controls. It is extremely important that these are not taken as homogeneously present and sufficient in all environments, and the tendency to do so has important ethical implications which may undermine dual-use awareness initiatives and the development of an ethical culture of awareness and responsibility.

Ethics education for life scientists regarding dual-use issues is a topic of considerable discussion. However, despite differences in opinions of pedagogy, current initiatives all aim to sensitize scientists towards the risks and dangers of dual-use issues, and to alert them to their responsibilities. In addition to the overarching responsibilities of beneficence and non-maleficence, the responsibilities of scientists are commonly held to be related to their position and their ability to act. This is contingent on support from the structures within which the scientist conducts research. It is inappropriate for support of the overarching principle of beneficence to force scientists into assuming responsibilities that are beyond their capacity as scientists and which are not expected of their international counterparts. Problems such as waste disposal and export controls, as illustrated here, not only undermine ethical teaching and practice through forcing scientists to choose between the assumed beneficence of their research and their duty towards non-maleficence, but also place unnecessary strain and responsibility on scientists.

It is important that ethical problems arising from (infra)structural issues are explicitly discussed within wider debates on dual-use ethics. Furthermore, these issues should not detract from the ethics education of scientists, nor present them with conflicting situations in which their ethical training is undermined by their environment. Greater transparency around these issues will play an important role in forming an international culture of awareness and responsibility, as scientists are provided with the tools and support to deal with the pressures of their individual environments.

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