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The Impact of Dual Use Controls on UK Science: Results From a Pilot Study

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The impact of dual use controls on UK science: results from a pilot study

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Introduction

Concerns about the proliferation of biological weapons and the threat posed by bioterrorism have assumed greater political prominence in recent years.[1] In response, governments are actively attempting to frustrate the diffusion of technologies, relevant to the production of biological weapons, to regimes and non-state actors which might develop and use such weapons. Their most recent efforts have involved the introduction of a range of new national measures to control access to materials, knowledge and technologies.

Preventing the diffusion of the necessary knowledge and technologies used to develop biological weapons is complicated because the underlying technologies often have legitimate and socially beneficial applications. Any controls to prevent their hostile application can also potentially disrupt legitimate activity, thereby generating social costs. For example, anecdotal evidence suggests that the introduction of biosecurity controls in the US and Germany are adversely affecting scientific research in those countries.[2] Governments therefore need to balance these costs against the security benefits that such controls generate.

To do this policy makers need information on the impact of these new 'biosecurity' measures. However, this is a new area of policy and few impact assessments have been performed. This pilot project, funded by the Economic and Social Research Council[3], developed and validated new methods for assessing the impact that UK government biosecurity policies, introduced to prevent legitimate scientific research from being misused, are having on the practice of science. This short report briefly explains the project and outlines a sample of the initial results.

What is dual use?

This project was concerned with 'dual use' technologies. Dual use is a term that is applied to the tangible and intangible features of a technology that enable it to be applied to both hostile and peaceful ends with no, or only minor, modifications.[4] Most peaceful applications are civilian in context, but there are also peaceful military applications, such as developing and producing vaccines against germ warfare agents. Hostile contexts have traditionally been thought of as military and state-based, but increasingly attention has been directed towards the possibility that non-state actors, such as terrorists, might use biological weapons.[5] The dual use nature of some of the relevant technologies and scientific knowledge raises the possibility that scientists engaged in legitimate research for peaceful purposes might have their work misused and applied to biological warfare purposes. This includes the possibility of inadvertent assistance through seemingly harmless activities, such as postgraduate teaching.

The 'dual use dilemma' faced by the many countries who are determined to take measures to reduce opportunities for biological weapons development is that, compared to hostile applications, there is a vast range of peaceful purposes. Moreover, these applications are spreading across the world and in many cases

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[1] United Nations Secretary-General, *A More Secure World: Our Shared Responsibility. Report of the Secretary-General's High Level Panel on Threat, Challenges and Change*, December 2004, G8 (2004), *Action Plan on Nonproliferation*, Sea Island Summit, 9 June 2004, G8 (2003), *Non Proliferation of Weapons of Mass Destruction: A G8 Declaration*, Evian Summit, 3 June 2003

[2] See for example, "An open letter to Elias Zerhouni" *Science*, Vol 307, Issue 5714, March 4th 2005; Cohen et al, "The pitfalls of bioterrorism preparedness: the anthrax and smallpox experiences", *American Journal of Public Health*, vol 10, 2004; Brumfiel G, "US universities up in arms over licence plans for foreign staff", *Nature,* vol 431, 2004; van Aken et al, "Biosecurity requires international supervision", *Nature*, vol 431, 2004; May T. "Isolation is not the answer", *Nature*, vol 429, 2004.

[3] The ESRC is an independent research council charged with promoting and supporting research into key issues of concern to social science.

[4] Molas-Gallart J and JP Robinson (1997), Assessment of Dual-use Technologies in the Context of European Security and Defence, Report for the Scientific and Technological Options Assessment (STOA), European Parliament.

[5] See for example, Interpol "Final Communiqué", 1st Interpol Global Conference, Lyon, France, 1-2 March 2005 as downloaded from http://www.interpol.int/Public/BioTerrorism/Conferences/FinalCommunique.asp

their diffusion should be encouraged rather than slowed down. Governing dual use technologies therefore poses a serious policy design dilemma: the regulatory regime needs to balance the suppression of negative applications (in order to reduce the risk of germ warfare) without hindering the development of technology for positive purposes.

The governance regime to do this has at its heart the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (BWC). This convention came into force in 1975 and currently has 153 state parties and 16 signatory states. The BWC obliges its member states

> never in any circumstance to develop, produce, stockpile or otherwise acquire or retain:
>
> Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
>
> Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.[6]

When implementing the BWC nationally, the United Kingdom, through the adoption of the *Biological Weapons Act* 1974, placed the obligation on all of its citizens "never in any circumstance to develop, produce, stockpile or otherwise acquire or retain: microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes".[7] The 1974 Act additionally obliges citizens not to transfer, enter into an agreement to transfer, or make arrangements under which another person transfers any biological agent or toxin "if the biological agent or toxin is likely to be kept or used (whether by the transferee or any other person) otherwise than for prophylactic, protective or other peaceful purposes and he knows or has reason to believe that this is the case".[8]

As well as implementing the BWC at the national level, governments use a range of other national policies to control the proliferation of dual use technologies. Most of these regulatory efforts aim to provide sufficient oversight of the possession and transfers of technology so that roadblocks can be put in place in time to stop the application of technology for illicit purposes. The most recent pieces of biosecurity legislation entered into UK law are the *Anti-Terrorism Crime and Security Act,* 2001 which amended the *Biological Weapons Act,* 1974 and placed new legal obligations on the scientific community to ensure their technologies are not misused and misappropriated, and the secondary legislation to the *Export Control Act,* 2002 introduced in 2004 which regulates the transfer of intangible technologies.

Project objectives and methods

The aim of this pilot project was to assist the successful design and implementation of policy by developing and validating new methods for gathering qualitative and quantitative data on the impact of biosecurity controls on UK science.

The project gathered data using questionnaires and interviews from a small sample of the UK scientific community. The sample was constructed using standard bibliometric methods based on a network of UK scientists who published peer-reviewed research between 1989 and 2004 relating to dangerous pathogens,

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[6] Article 1, *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction*, 1972.

[7] Article 1, *The Biological Weapons Act*, United Kingdom, 1974.

[8] Article 1A, *The Biological Weapons Act*, United Kingdom, 1974 (as amended by the *Anti Terrorism Crime and Security Act,* 2001).

as defined in Schedule 5 of the *Anti Terrorism Crime and Security Act,* 2001.[9] The original dataset was then cleaned up and triangulated with other datasets to provide a core sample of 100 scientists. A control group, not engaged in research using Schedule 5 agents, was also selected from the broader scientific community. This control allowed the research finding to be placed in a wider context and allowed the research team to evaluate how representative the views of our sample were.

The development, piloting and validation of the questionnaire was undertaken in collaboration with both the security and scientific communities over a six month period. This involved an iterative process of finding unambiguous terminology and becoming aware of the specific issues facing different communities. Once the questionnaire was piloted, it was sent to all 128 members of the sample - scientists, funders of science, biosafety officials and security officials.

Interviews were also conducted with 27 members of the sample to explore at a deeper level the individual answers received and to test the general trends emerging.

The project achieved a 53% response rate (68 usable responses).

Who participated?

The scientists in our sample all worked with agents listed in Schedule 5 of the 2001 *Anti Terrorism Crime and Security Act* (71% with the pathogens, 76% with Schedule 5 toxins and 91% with the genetic material associated with the action of either the pathogens or toxins).

The majority of our scientists and biosafety officials were located within universities or other teaching institutions (68%), although government laboratories (9%) and commercial R&D (6%) were also represented. Institution size was typically between 11 and 100 active researchers, although a number of smaller institutions with less than ten active researchers were also represented. The institutions contained the necessary equipment and infrastructure to perform work at hazard group 2 (91%) and hazard group 3 (74%), as detailed in the 2002 *Control of Substances Hazardous to Health Regulations*.[10] Seventy-nine per cent of the institutions were able to work with toxins or with genetic material associated with the action of pathogens or toxins under conditions of containment.

Given that the sampling method focused on the core of a network, the respondents were more senior, better networked and more experienced than the typical member of the UK scientific community would be. For example, 71% of the scientists held positions of overall responsibility for research projects using Schedule 5 agents, 68% were day-to-day managers of laboratories, and just over half of the scientists (53%) actively engaged in research with Schedule 5 agents. Many of the participants indicated having experience as biosafety (44%) and/or biosecurity advisors (24%).

Over half of the total sample, 56%, described themselves as previously involved with biosecurity issues including interactions with relevant government officials.

What did the project find?

The project produced three basic findings of policy interest:

[9] The *Anti Terrorism Crime and Security Act* details in Schedule 5 a number of pathogens and toxins which require special security measures. These include if requested notification before keeping or using the substances; information about who has access; and a requirement to provide, if necessary, physical security details. The list currently contains 19 viruses, 5 rickettsiae, 13 bacteria and 11 toxins and includes any genetic material associated with the pathogenicity of the micro-organism, and any genetically modified organism containing any such sequence.

[10] Schedule 3, Additional Provisions Relating to Work with Biological Agents, Part 1, Provisions of General Application to Biological Agents, *The Control of Substances Hazardous to Health Regulations*, United Kingdom, 2002.

The first finding is that the implementation of new biosecurity measures in the UK seems not to have had the same negative impact as has been reported in the US and Germany. This unexpected finding is important because it suggests that biosecurity policy options do not have to involve a trade-off between advances in scientific research and security. While clearly it is possible that advances in scientific understanding can increase the risks of misuse, and, similarly, that draconian security measures could disrupt science, this finding suggests that, at present, this is not *necessarily* the case.

The second finding is that the success of this implementation was related to three factors (1) pre-existing security and biosafety measures; (2) a responsive approach to regulation by the implementing body; and (3) a flexible and socially responsible reaction by this sample of the scientific community. Had any one of these conditions not been in place, the costs could have been substantially higher, but together they have contributed towards a successful initial implementation.

The third finding is that while the initial stages of the implementation process built on these success factors, future implementation is likely to be more difficult. The implementation of wider security measures will have to move beyond 'piggybacking' on pre-existing security and biosafety measures and will require a greater degree of interaction between the scientific and security communities.

Specific findings

This section will briefly run through some of the specific findings of the pilot project as they relate to operational procedures, impact of the new requirements and perceptions held by our sample about biological warfare issues.

Channels of communication

Our sample received most of their information about changes in biosafety or biosecurity regulations through channels of communication which have been designed primarily for the distribution of health and safety information. Our sample indicated that their main sources of information were targeted distributions from the Health and Safety Executive (85%), whilst 59% of the sample performed proactive scanning of health and safety websites. However, over half the sample (53%) also received information from targeted distribution by governmental departments such as the Department of Trade and Industry. Only 15% actively scanned other sources for information, which included those primarily handling biosecurity issues.

The preference for health and safety channels reflects the long-established, close links between the biosafety and scientific communities that have been used to successfully implement a range of regulations on scientific practice since the 1970s. This is important because it highlights how the UK scientific community was already subject to regulations before the introduction of new biosecurity controls, and that this earlier implementation of these biosafety regulations created a link between government and science.

Procedures in place before 2001

One of the main factors which has influenced the level of costs associated with introducing new biosecurity controls in the UK seems to be the existence of a range of procedures at institutions before the introduction of the *Anti Terrorism Crime and Security Act* in 2001. Many organisations in the sample had pre-existing procedures for the purposes of either biosafety obligations or concerns about animal rights terrorism. These procedures also functioned as biosecurity controls and helped reduce the costs of implementing the security requirements attached to Schedule 5 pathogens and toxins. For example, the majority of our respondents reported their institutions as having procedures to monitor the acquisition of dangerous material (71%) and disposal of equipment (71%) which pre-dated the obligations found in the *Anti Terrorism Crime and Security*

Act, 2001. Similarly, 71% and 74% of the sample reported that access to laboratories and data by occasional visitors and short-term workers was controlled in their institutions prior to 2001. There were similar pre-existing controls in place in over half the institutions to govern the transfer of dangerous materials on-site (56%) and off-site (65%).

Changes in operational procedures since 2001

Notwithstanding these existing procedures, our sample indicated that substantial changes have occurred in the operational procedures of their institutions since 2001. When asked about those changes, the sample reported that more attention is now being given to: biosafety obligations (79%), risk assessments (68%), material safety (53%), material transfer (56%), and ethical reviews (47%). Whilst a substantial number of the sample (41%) reported their institutions as having had in place procedures to review personnel with current access to controlled pathogens prior to 2001, only 26% reported an increase in that activity since the introduction of the *Anti Terrorism Crime and Security Act*, 2001.

When asked what the sample believed had caused these procedural changes, the majority of our sample (74%) believed they were the result of the new legal requirements but almost half (41%) believed that other pressures, such as the increased activities of animal rights protestors, might have been responsible.

Benefits: new funding contracts and partners

Only a small subset of the sample (15%) reported having received any direct benefit from the increased attention to biosecurity since 2001. Of those that did record a benefit, it typically took the form of winning new contracts or collaborative partners. The small number of participants that had moved into new areas of R&D (15%) did so mainly for financial reasons. Only one institution listed as a benefit the increased opportunities for discussion with government officials on the validity of these measures. Whilst these numbers seem low, it is important to note that 26% of our sample thought that it might be too soon to judge whether they could experience any benefits. In the USA, concerns about bioterrorism have opened up new funding sources for research, and it is conceivable that our sample may benefit from this in the future.

Costs: experiences of major complications or setbacks in the last three years

Although some of the sample has experienced benefits, the project also gathered data on a range of costs that have been experienced since 2001. Forty one percent of the sample indicated having experienced no major complications or setbacks in the last three years. However, our sample did indicate that four research projects have had to be abandoned as a direct result of the recent increase in national and international attention to the need to prevent science and technology from being diverted into biological warfare or bioterrorism purposes. Despite this low number, a large proportion of the sample reported experiencing other 'major complications or setbacks' over the last three years. The issue causing the most complications or setbacks was the difficulty in obtaining pathogens and toxins, but other issues have also caused major complications such as increased mandatory biosafety requirements (15%), increased mandatory biosecurity requirements, and changes to waste disposal requirements (both experienced by 12% of the sample).

Further investigation of these results found that those who had experienced these 'major complications and setbacks' believed they were as much a result of changes in US biosecurity controls as changes in UK requirements. The influence of US regulations on UK science reaffirms the global nature of science and consequently indicates the global impact of any form of biosecurity control.

Which policies are worth considering?

Our sample was presented with a list of current biosecurity policy options and asked which they would consider as a means to strengthen the biosecurity norm. The figures presented in Table 1 indicate respondents who thought the measures were worth considering, rather than respondents who supported such measures.

Table 1: Views on biosecurity policy options

CURRENT POLICY OPTIONS TO PROTECT AGAINST MISUSE	PERCENTAGE WHO WOULD CONSIDER THAT OPTION
Increased security checks on all personnel currently working with dangerous pathogens, toxins or genetic material	62%
Increased screening of all new personnel with future access to dangerous pathogens, etc.	62%
Requiring procedures to authorise and control off-site transfers of dangerous pathogens, etc.	56%
Increased requirements for material control in institutions	53%
Scrutiny by funding bodies considering R&D proposals	47%
Scrutiny by scientific journals when papers are submitted	47%
More rigorous (safety) risk assessment of proposed work	41%
More rigorous ethical review of proposed work	41%
Codes of conduct	32%
Denying access to nationals from countries of concern to dangerous pathogens, etc.	21%

These results indicate that the sample are willing to consider a wide range of possible policy options, but prefer options that do not unduly hinder research or teaching.

Further investigation of the reasons for lack of support for more rigorous safety or ethical assessment found a widespread belief that current levels of risk assessment and ethical review were adequate and that further rigour would impede research. It was also discovered that the limited support for the last two options was due to a lack of understanding of their underlying logic. For example, the sample failed to see how implementing a code of conduct would strengthen biosecurity or help to ensure an effective biosecurity norm across the UK science base.

In the case of the last option, only 21% of the sample believed that denying access to nationals from countries of concern was an option worth considering. This result seems to conflict with the high scoring options of increased security checks on all personnel with current or future access to dangerous pathogens. This suggests the presence of other factors in the samples' decision-making processes. The project found that one such factor is the support for the cultural norm of universality of participation in research irrespective of an individual's nationality.

Who ought to have responsibility for protecting against misuse?

When asked who ought to be responsible for protecting against the possible misuse of the life sciences, our sample favoured self-governance by the institutions themselves (76%) and the scientific community at large (71%). There was also a preference for funding bodies to take responsibility for assessing risk before research takes place rather than for scientific journals to address the risks after the research is completed (a 59% to 29% preference). Reasons given for the high preference toward some form of self-governance were based on a response to frustration caused by "overly complex and bureaucratic regulations".

However, the sample generally recognised that some form of government participation was necessary. Fifty-eight per cent of the sample believed that of the options they would consider to strengthen the biosecurity norm, the best practice for implementation would be through formal regulation by government only after consultation with members of the scientific community. Participants explained the need for formal regulation as ensuring "consistency", "uniformly high standards of design and implementation" and application "across the board". Mention was also given to the need for "outside auditing and regulation with sanctions that pose a real threat to those that do not comply" indicating some scepticism about self-regulation.

Of the options given, a marked preference was given for a focal role in the development and implementation of formal regulations to be given to government departments with which the sample have pre-existing relationships, such as the Health and Safety Executive (68%) or the Department of Trade and Industry (32%). Of those government departments primarily involved with non-health and safety issues, 47% of the sample preferred the involvement of the Home Office or the Security Services.

Analysis

When interpreting the results from this report it is important to recognise that this was only a pilot project. Care must therefore be taken in drawing conclusions or policy implications, as results are indicative rather than conclusive. However, having noted these caveats this subset of the project results does suggest that the implementation of new biosecurity controls in the UK has been conducted very successfully. The project found that 79% of our sample regarded the current balance in the UK between scientific freedom and security as satisfactory.

It is, of course, possible that the research was undertaken too early. New legislation or improperly handled implementation has the potential to generate substantial future costs. However, the lack of substantial disruption is an important finding as it suggests that science and security do not necessarily have to be in conflict with one another.

As already noted, the research suggests three factors that have contributed to the successful implementation (thus far) of UK biosecurity controls:

1. Pre-existing biosafety measures which ensured a degree of biosecurity;
2. A responsive approach to regulation by the implementing body; and
3. A flexible and socially responsible reaction to the new controls by the UK scientific community.

Factors influencing successful implementation 1: biosafety and biosecurity

One of the main contributing factors for the successful implementation thus far of the obligations in the *Anti Terrorism Crime and Security Act*, 2001 has been the high level of pre-existing biosafety procedures that can

also function as biosecurity measures. The links between biosafety and biosecurity have been a recurring theme in this project.

Scientific activity in the UK has been heavily regulated since the 1970s through successive health and safety measures. The *Health and Safety at Work Act*, 1974 for example:

> [I]ntroduced a broad goal setting, non-prescriptive model, based on the view that 'those that create risk are best placed to manage it'. In place of existing detailed and prescriptive industry regulations, it created a flexible system whereby regulations express goals and principles, and are supported by codes of practice and guidance. Based on consultation and engagement, the new regime was designed to deliver a proportionate, targeted and risk-based approach.[11]

That 'flexible system' has since created procedures to deal with the acquisition of dangerous material, access to laboratories and data by visitors and short-term workers, and the transfer of dangerous materials.

Although biosafety and biosecurity are fundamentally different – biosafety being concerned with protecting the health and safety of workers and the environment whilst the central concern of biosecurity is unauthorised acquisition – the norms are compatible and it can be argued that the implementation of UK biosecurity measures has drawn heavily on the biosafety model. The new biosecurity legislation, for instance, has concentrated on tightening existing practices rather than introducing radically new requirements. Indeed some of the procedural changes introduced into UK laboratories since 2001, such as more rigorous risk assessment procedures, increased material safety requirements, and improved recording and regulation of the possession and transfer of dangerous materials, may have occurred as a result of the periodic reviews of biosafety that have become the practice in UK workplaces, rather than specifically in response to biosecurity legislation and government inspections.

This suggests that partial determination of the variation in national and international implementing costs of biosecurity policies (e.g. disruption to research, additional spending) might be explained by the extent of pre-existing national biosafety regulations. Furthermore, this suggests that the costs of implementation might be substantially higher in institutions with lower levels of health and safety procedures. Given that the sample was biased towards scientists working with dangerous human pathogens, extending the implementation process beyond Schedule 5 of the *Anti Terrorism Crime and Security Act*, 2001 may generate more substantial costs.

Factors influencing successful implementation 2: the implementation process

Effective implementation of any biosecurity control on dual use technologies is challenging because it has the potential to impose substantial costs upon legitimate actors. Further, effective implementation requires the co-operation of the scientific community, many of whom will not have had previous contact with the security community. Given the cultural differences between the 'open' scientific community and the 'closed' security community, care is needed to avoid a clash of cultures. [12]

Given these difficulties, the second factor which has influenced successful implementation has been the actions of the implementing body – the National Counter Terrorism Security Office.[13] This body has come

[11] Health and Safety Executive *Thirty Years on and Looking Forward: The Development and Future of the Health and Safety System in Great Britain,* 2004.

[12] Atlas R, "National security and the biological research community", *Science,* vol 298, no 5594, 2002.

[13] The National Counter Terrorism Security Office (NaCTSO) is a specialist police organisation co-located with the Security Service in the National Security Advice Centre. For more information see http://www.mi5.gov.uk/output/Page163.html#police

close to producing a textbook example of successful change management. The implementation of new regulations has exploited pre-existing links and channels of communication between the biosafety and scientific communities and used them as avenues into the scientific research community. The implementation process has thus far been non-confrontational and, because of the role given to biosafety officials, has to some extent been responsive to the organisational culture and work practices of the scientific community.

However, only 21% of the sample believed that the police ought to have responsibility for protecting against the misuse of the life sciences. Given the bias in the sample, this result suggests that practising scientists favour the use of other mechanisms to protect the life sciences against misuse. One participant explained that there were good interactions between officials and university biosafety staff "but a great deal needs to be done to get leaders of research projects involved. They will be at the front line when implementation is required". It is possible therefore that the current low level of support may increase once direct communication occurs between the police and practising scientists.

Factors influencing successful implementation 3: the response of the scientific community

The third factor influencing successful implementation has been the proactive response of the sample.

The scientists interviewed repeatedly expressed a recognition that scientific research does not exist within a moral or social vacuum and that they, as scientists, have to be responsive to changes in society. As a result, they were inclined to take a flexible and proactive approach to risk management. Even in situations where the sample thought that the risk assessments were unrealistic, they recognised the need to be responsive to public concerns and to take into consideration not just risks, but also the public's concerns and perceptions about those risks.

Although general awareness within the sample about current issues related to preventing legitimate science and technology being misused was quite low, there was a much higher level of awareness about how a scientist engaged on legitimate work might unknowingly contribute to the development of biological weapons or to bioterrorism. For example, participants believed that a scientist could unknowingly contribute by manipulating an organism to "overcome natural and therapeutic controls", by "inappropriate release of information", or "by making loans or gifts of equipment". Many in the sample believed that their awareness of the issues could improve if there was an opportunity for increased interaction with the government officials who design biosecurity policies.

The respondents also regularly reflected on the unintended consequences of different policies because of what the sample regarded as a lack of appreciation of the subtleties of scientific research. For example, policies based on the constraint of dissemination of information at the publication stage were considered inappropriate because the research methodology and findings would already have been publicised at conferences. Similarly, controls restricting the number of foreign nationals with access to dangerous pathogens were considered problematic in an environment where universities are actively encouraged to increase their foreign student numbers.

Many in the sample repeatedly expressed their desire to be better guardians of their science and wished to be more actively involved in the process of developing effective UK biosecurity policies by offering their scientific expertise and cultural knowledge. These participants felt they could be better guardians if they had better understanding of the types and risks of misuse, and of the logic underpinning regulatory measures such as control lists and export licences.

Their desire to have more active engagement with biosecurity officials is unlikely to be a result of any perceived direct benefit, as only 15% of the sample had received any. Their desire is more likely to stem from

revulsion at the possibility of their legitimate research being misused and concerns about the impact of inappropriate regulations.

Risk management and the scientific community

Although this pilot project only explored a very specific part of security policy with a very small sample of scientists, it does suggest that there has been a major change in how the scientific community conceives of risk and attempts to manage it. On several occasions our interviewees stated that the BSE disaster had fundamentally changed the way that British society was prepared to accept risk assessments from scientists. Similarly, the House of Lords Select Committee on Science and Technology report on *Science and Society*[14] drew attention to how the British public was increasingly unwilling to accept scientific statements in an unquestioning manner. Partly in response to these changes, interviewees noted that the social legitimacy of scientific knowledge is increasingly dependent on scientists engaging with wider society, suggesting that the proposals of the Royal Society report on the management of scientific risk have been adopted.[15]

Clearly the project was drawing on a self-selecting sample of interviewees who, by agreeing to be interviewed, were already more likely to be inclined to engage outside their disciplines. However, the consistency of their responses suggests that there is at least a subpopulation of the scientific community that not only recognises the risks of misuse of scientific knowledge, but also recognises the importance of public perceptions of that risk, and their role in responding to those perceptions. This reflexive nature can be seen by the fact that while 47% would consider editorial scrutiny of papers at publication, only 39% believed the process would reduce the risks of misuse. This indicates that at least some thought that such policies should be considered either because they might be effective for unintended reasons, or because they considered them effective ways of dealing with other concerns and perceptions.

Interviews suggested that the scientific community was prepared to expend considerable effort engaging with the wider community to generate and maintain what Gibbons and colleagues call 'socially robust knowledge'.[16] In the context of biological weapons non-proliferation this involved recognising the uncertainties surrounding risk assessments and a focus on processes that manage and reduce unknown and possibly unknowable risks. This focus on improving risk management processes is reflected in the support for the Health and Safety Executive as the preferred medium through which government should enact regulations. The Health and Safety Executive has a long established working relationship with the scientific community and focuses on allowing scientists to exploit their expert knowledge of local situations to create more effective policy. While the academic social science literature has called for the scientific community to be more reflexive in its approach to risk management, our results, though only tentative, suggest that at the micro-level this has already happened. The policy issue is therefore not about changing scientists' understanding of risk, but of providing them with the time and resources they need to effectively engage with the policy making process.

Final reflections

The results from this pilot project seem to indicate that thus far, the implementation of UK biosecurity controls has been carried out with limited negative impact on the scientific community. It thus appears that post 9/11 changes in attitudes and procedures within the scientific community working with controlled pathogens have been less disruptive in the UK than in the US and German scientific communities.

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[14] House of Lords Select Committee on Science and Technology, *Science and Soci*ety, HMSO, March 2002.

[15] Royal Society *Risk: Analysis, Perception and Management,* Second edition, London: UK, The Royal Society, 1992.

[16] Gibbons M, C Limoges, H Nowotny, S Schwartman, P Scott and P Trow, *The New Production of Knowledge*, London Sage, 1994.

As already mentioned, it is possible that this research was undertaken too early, and that future legislation or improperly handled implementation has the potential to generate substantial costs to UK science. As such it will be necessary to regularly review the impact of dual use controls on UK science. This project has developed and validated a methodology to identify relevant members of the scientific community and obtain such information.

One participant highlighted the need for a two-stage implementation process of national biosecurity measures – the first stage involving securing adherence with minimal costs, the second stage involving a long-term culture change in the scientific community. With the first stage being conducted successfully, implementers can now turn their attention to the longer-term objective of a cultural change within the scientific community. This project has shown that this may require a change to the type of engagement currently conducted between the scientific and security communities, to take into consideration the norms and practices of the scientific community. An appreciation of these norms will reduce potential resistance to new or extended biosecurity legislation and may encourage full and effective participation by the scientific community in UK efforts to reduce the threat from biological weapons.

The research team

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