Foresight Infectious Diseases China Project - A novel approach to anticipating future trends in risk of infectious diseases in China: methodology and results from an initial application

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The project devised a simple but novel methodology for identifying possible future trends in infectious diseases in animals and humans in China, of priority concern to the Chinese authorities. It used a model of disease drivers (social, economic, biological or environmental factors that affect disease outcomes, by changing the behaviour of diseases, sources or pathways) devised for the Foresight Programme in the United Kingdom. Nine families of drivers were adapted to Chinese circumstances and matrices were constructed to identify the likely relationship of single infectious diseases or families of diseases to the drivers. The likely future trends in those drivers in China were determined by interviews with 36 independent Chinese experts. These trends included not only potentially adverse animal and human movements but also opportunities for innovative surveillance methods, more use of hospitals, antimicrobials and vaccines. Some human behaviours and social trends were expected to increase the risk of infections (in particular sexually transmitted and healthcare-associated infections) while at the same time the experts thought the awareness of risk in the Chinese population would increase. The results suggested a number of areas where the Chinese authorities may experience difficulties in the future, such as rising numbers of healthcare-associated infections, zoonoses and other emerging diseases and sexually transmitted infections (including HIV). Not making firm predictions, this work identifies priority disease groups requiring surveillance and consideration of countermeasures as well as recommending strengthening basic surveillance and response mechanisms for unanticipatable zoonoses and other emerging disease threats.

Introduction

In 2006 the United Kingdom (UK) government published the final results of the *Foresight Project on the Detection and Identification of Infectious Diseases* (September 2004 - April 2006). This produced a vision on risks from infectious diseases in plants, animals and humans over the next 10 to 25 years [1-5]. Particular emphasis was placed on how external factors or *drivers* (defined as social, economic, biological or environmental factors, see Table 1) could lead to changes in patterns of disease [6]. The project was international in scope with an intention to inform practical policies by showing how health threats can be anticipated, detected, prevented and controlled or at least how their effects can be mitigated in any country.

Based on this experience, a Project Group, including the authors, applied this future risks approach to China where there was both a recent history of emerging and changing infectious diseases and an especially rapid social change and therefore there was particular relevance for such an application [7]. These preliminary results were used to predict the more likely changes in infectious diseases and thus inform surveillance priorities, while at the same time refining and improving the Foresight methodologies for a later and larger application. The objective of this paper is to describe the methodology that was developed for the Foresight Infectious Diseases China sub-Project (hereafter referred to as *the China Project*) and the results of its initial application in China.

Methods

A workshop was held at the Health Protection Agency in the UK where objectives for the China Project work were agreed. The overall goals reflecting the policy priorities of the Government of China were to improve human health, to sustain economic development and to promote social stability as stated by the Chinese authors [8]. The specific objective was then to identify groups of human and animal infections that would be most likely to pose problems and challenges to these policy priorities in the next two decades. The rationale was that this would allow authorities to prioritise these groups for purposes of surveillance, prevention and control or mitigation.

The approach developed by the Future Risks component of the main Foresight Infectious Diseases Project was to have a simple model of drivers, sources, pathways and outcomes (Figure) [5]. *Drivers* would be a range of factors, social and otherwise (Table 1) that directly or indirectly can influence the incidence of infectious diseases. Sources were defined as phenomena or biological events that give rise to potential new diseases, enable existing diseases to become more harmful, enable existing diseases to infect new hosts, or enable existing diseases to spread to new areas, *pathways* were

Table 1

Nine groups of societal drivers (total = 96). Foresight Infectious Diseases China Project.

A. Governance and social cohesion
• Biosecurity governance of technology (drugs and pesticides)
• Social cohesion as an enabler or constraint on identification and control of infectious diseases
• Illegal practices and consequent spread of diseases of 'pest' species such as myxomatosis
• International/national/regional interactions affecting governance
• Lack of interaction between policy and regulatory agencies leading to delays in detection and identification
• Inter-ministerial agencies
• Openness with the public
• Marginalisation of some groups
• Political leadership on health issues
B. Demography and population change
• Immigration
• Urbanisation
• Migrant labour
• Overall population
• Ageing population
• Dietary and occupation changes (affecting exposure and susceptibility of population to disease risks)
• Population movements (e.g. from rural to urban or from developing to developed world)
• Animal immigration
• Overall animal populations
• Urbanisation of animals
• Animal population movements
• Movement of animals around the country
C. Conflict
• Difficulties in maintaining administrative systems and so loss of effective identification and surveillance systems
• Movement of refugees spreading diseases
• Internal conflict
• Loss of effective identification and surveillance systems for animals
• Unrestricted movements of animals around the country
D. Technology and innovation and their governance
• Impact of innovation on disease identification and treatments
• Ability to control infections; control strategies, e.g. for diseases that are easier (SARS, smallpox) or more difficult ('flu, AIDS) to control
• Impact of GM crops on agriculture and development of plant diseases
• Emergence of drug or pesticide resistant strains of infectious organisms; half lives of existing drugs and pesticides
• Role of technology in disease surveillance systems (detecting new, emerging diseases or monitoring movements of existing pathogens)
• Dissemination of information
• New, faster identification of organisms
• Development of new antivirals and vaccines
• Improved diagnostics, leading to more accurate, less costly and more rapid detection of diseases
• Transplant surgery
• Other high technology medicine
• More use of antimicrobials for humans
• Longer survival of patients with chronic diseases
• Longer survival of patients with chronic diseases
• Ability to control infections and improved control strategies in animals
• Drug or pesticide resistant strains in animals
• New surveillance systems for animal diseases
• Greater information dissemination (web-based information for disease diagnosis, for alerting experts to existence of new diseases, for providing faster and better public dissemination of disease-related information)
• Faster identification of infections in animals
• Use of antimicrobials in animals
• Improved diagnostics for animal infections

E. Changes in agriculture and land use
• Changes in animal husbandry methods, e.g. intensive rearing methods or closer missing of animal and human populations as part of urbanisation
• Greater genetic uniformity in animal and plant populations; less 'biodiversity', less varied crop mosaics
• More intensive farming systems
• Development of new crops
• New developments in production economics involving greater movement of animals and hence more exposure to diseases such as foot and mouth disease
• More frequent proximity of different farming systems
• Changing patterns of land use
F. Economic factors (income, prosperity, employment)
• Overall wealth
• Income disparity
• Education levels in the general population
• Future oil and other energy supplies
• Quality of sanitation and water supplies
• Background pollution levels affecting the natural immunity of animals and humans
• Poverty and malnutrition
• Waste disposal as a source of disease spread (humans)
• The availability of a pool of experts to detect and identify infectious diseases
• Unemployment
• Waste production and disposal in animals
• Pool of experts in animal health
G. Trade and market related factors
• Changing patterns of trade in crops and animals
• Behaviour and structure of markets
• Future diets and demands for exotic products
• Illegal trading in human foods
• Food preservation technology
• The misuse of disease surveillance systems as trade barriers
• Changing patterns of trade in animals
• Illegal trade in animals
•Trade barriers to trade in animals
H. Transport and tourism
• International movement of drug or vaccine resistant strains of organisms
• Changes in the rates of internal movements of people, food, animals etc
• Future levels of tourism to and from China
• Levels of internal tourism
• Changes in patterns of stock-keeping and so movement of diseases; compressed time scales
• Internal migration
I. Human activity and social pressures
• Demands for more healthy food
• Demands for more 'sustainable' production systems
• Changes in sexual practices
• Changing life styles – consumerist, individualist, communitarian
• Public perceptions of risk and willingness to change behaviours
• Public demands for greater levels of safety
• Demands for lower levels of pollution
• Ecological awareness in the public
• Public willingness to accept change
• Media reporting as a driver of how governments react to disease
• Crowding in hospitals
• Farmers and producers perception of risk and biosecurity
• Willingness to change farming practices
• Media reporting on animal health issues

mechanisms or routes by which a disease-causing organism can be transferred from one host to another, within or between species and outcomes were the infectious diseases themselves [5]. For example, changes in the way animals are reared for food production favouring intensive farming and the keeping of animals in close proximity in large numbers would lead to the spread of zoonoses that by definition affect humans.

For the China Project the Future Risks model was developed to make predictions relevant to the Chinese situation. The Project Group identified drivers, considered what was known of their relationship to important groups of animal and human infections (plant infections were outside their expertise). It then determined through consultation with Chinese experts what was thought to be likely to happen to the drivers in the next two decades in China and hence assessed qualitatively what might be expected to occur in regards to the spread and prevalence/incidence of these infections in China over that time.

Figure

Basic Foresight risk model for infectious disease risks

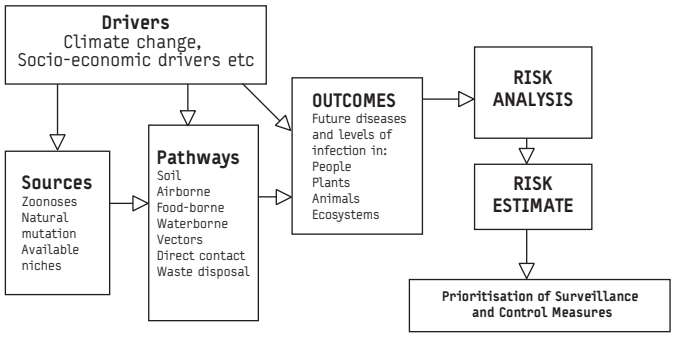

Table 2

Selected animal and human diseases. Foresight Infectious Diseases China Project

Exemplar animal infections
Foot and mouth disease
Avian influenza
Classical swine fever
Bovine spongiform encephalopathy
Selected groups of human infections
Gastrointestinal infections
HIV and other sexually transmitted infections
Malaria and other vector-borne infections
Influenza
Severe acute respiratory syndrome (SARS)
Parasitic infections
Vaccine preventable diseases
Antimicrobial resistant organisms
Zoonoses (taken to include novel infections and novel variants of previous infections)
Healthcare-associated infections
Bloodborne infections

In detail, the Project Group used the drivers established for the main Foresight Project, and adapted these to reflect changes known to be underway in China focusing only on animal and human diseases. As a result a list of 96 drivers grouped into nine families was obtained (Table 1). These included:

- Factors that affect the sources of the infectious disease (e.g. changes in patterns of animal husbandry)
- Factors affecting how infectious diseases are spreading (e.g. changes in the movement of people and changes in institutional structures)
- Factors affecting the assets at risk (businesses, people, animals)
- Factors that are likely to influence vulnerabilities to infectious diseases (e.g. increasing numbers of elderly people and people living with chronic diseases)
- Changing priorities and requirements for surveillance to detect anticipated risks and changes in risks (e.g. detection of healthcare-associated infections)
- Priorities and opportunities for control of risks and diseases (e.g. appreciation of the need for biosecurity around the controlled use of dangerous pathogens in laboratories and industry)

For animal diseases, four exemplar infections were chosen by the veterinary experts in the Project Group to represent both known infections (foot and mouth disease and classical swine fever) and emerging or novel infections (avian influenza and bovine spongiform encephalopathy). While the approach taken for human diseases was to identify 11 important families of infectious diseases or single diseases (Table 2).

The Project Group then used their expert knowledge to populate the two-dimensional matrices establishing the causative relationships or associations between the drivers and the infectious diseases (examples in the Appendix). For instance, recognised drivers increasing the risk of human immunodeficiency virus (HIV) infection and other sexually transmitted infections included adverse changes in sexual behaviours, increasing migrant labour, decline in educational levels and falls in the earning capacity of women. Conversely, the opposite trends in these drivers might be expected to lead to decreases in sexually transmitted infections, including HIV. These relations are shown in Table 3 for HIV and other sexually transmitted infections as an example [9]. The Group recognised that the relationships between some of the drivers and the animal and human infections were uncertain and therefore these cells were not populated in the matrices.

The main data gathering consisted in obtaining expert opinion from Chinese scientists on the likely future trends in the drivers in their country. A detailed structured questionnaire was developed and piloted within the Project Group itself. Some questions were asked more than once in different forms in order to check on the consistency of answers. Following approval from the Ethics Committee of the Chinese Academy of Medical Sciences, Peking Union Medical College (PUMC), 36 Chinese experts (four per each family of drivers) were identified by the Chinese collaborators in the Project Group from the Chinese academic community (personal details of the experts are not disclosed in this paper but are available from the authors upon request). The selection was based on relevant expertise in the families of drivers in China rather than knowledge about infectious diseases.

The expert opinions were then derived from face-to-face interviews undertaken by a team of postgraduate students from PUMC using the questionnaire. The experts were asked whether

in their opinion the drivers were going to worsen, improve or stay the same in the next two decades. For example, a question from the section on Transport and Tourism (Family H of the drivers) was phrased as follows: *Concerning internal migration in the next 15 to 20 years do you expect this to increase, decrease or stay the same?* Experts could also say that the future situation was genuinely uncertain, or that they had no opinion. Notes were kept of additional remarks and comments made by the experts. The students who performed the interviews were trained so as to achieve consistency in the process and this was checked by repeating 10% of interviews with a different student.

The results of the 36 interviews were analysed in China to arrive at consensus expert views on the likely future trends in the drivers. Consensus was considered to have been achieved where three out of four or all four of the experts agreed.

These consensus trends were then applied back to the matrices (Tables 3 and 4) to identify which of the animal and human diseases would be more likely to increase or decrease in the future in China.

After the work the authors held a meeting in Beijing and reviewed the experience to indicate lessons that should be taken into account in the future use of this methodology ('lessons learnt') planned in China.

Results

Expected trends in the drivers

Of the 96 drivers, consensus was achieved for 51 while for further three drivers the experts agreed the future was uncertain. For 23 of the 51 there was complete consensus between the four experts while for 28 there was only consensus between three out of four experts. These detailed results are shown in Table 5. The drivers for which there was consensus are listed in Table 3.

Table 3

Example of the relationship between drivers and infections – Human Immunodeficiency Virus (HIV). Foresight Infectious Diseases China Project.

Factors likely to be associated with...	... increased HIV transmission	... reduced HIV transmission
Governance and social cohesion	Decreasing social cohesion Increasing illegal practices Marginalisation of some groups	Increasing political leadership on health issues Increasing openness with the public
Demography and population change	Increasing urbanisation and use of migrant labour Increasing population movements (e.g. from rural to urban or from developing countries to China)	Ageing population
Conflict	Movement of refugees spreading diseases Internal conflict	
Technology and innovation and their governance	Emergence of drug resistant strains Longer survival of patients with chronic diseases	Impact of innovation on disease identification and treatments Dissemination of information New, faster identification of organisms Development of new antivirals and vaccines Improved diagnostics, Greater information dissemination
Economic factors	Greater income disparity Increased poverty Unemployment	Increased overall wealth Improved education levels
Transport and tourism	International movement of drug-resistant strains Increases in the rates of internal movements of people More tourism to and from China	
Human activity and social pressures	Changes in sexual practices to more unsafe sex More injecting drug use	Public demands for greater levels of safety Public perceptions of risk and willingness to change behaviours (if unsafe sex) Media reporting as a driver of how governments react to disease

Table 4

Areas of expert consensus on future trends in drivers. Foresight Infectious Diseases China Project.

A. Governance and social cohesion
• Social cohesion will increase
• International/national/regional interactions will increase
• Government openness with the public will increase
• Political leadership on health issues will increase
B. Demography and population change
• Use of migrant labour will increase
• Human population movements will increase
• Animal immigration into the country will increase

• Urbanisation of animals will increase
• Internal animal population movements will increase
• Movement of animals around the country will increase
C. Conflict
• Stress on administrative systems will increase and with it will there will be loss of effective identification and surveillance systems
• There will be some loss of effective identification and surveillance systems for animals
D. Technology and innovation and their governance
• There will be more innovation in disease identification and treatments for humans
• The potential to control human infections will generally increase
• The emergence of drug or pesticide resistant strains of infectious organisms will increase
• There will be more opportunities for innovative disease surveillance systems (detecting new, emerging diseases or monitoring movements of existing pathogens)
• The ability to disseminate information will increase
• The ability to identify organisms will increase as will the speed of identification
• Numbers of new antivirals and vaccines will become available
• Diagnostic ability will improve , leading to more accurate, less costly and more rapid detection of diseases
• High technology medicine will increase
• Use of antimicrobials for human infections will increase
• Identification and treatment of human diseases will increase
• Ability to control infections in animals will increase
• Drug or pesticide resistant strains appear more often in animals
• There will be more opportunities for developing surveillance systems for animal diseases
• Information dissemination about animal disease will increase
• Infections in animals will be identified more rapidly and easily
• There will be more use of antimicrobials in animals
• There will be improved diagnostics for animal infections
E. Changes in agriculture and land use
• The genetic uniformity in animal and plant populations will increase
• There will be developments in production economics involving greater movement of animals and hence more exposure to diseases such as foot and mouth disease
F. Economic factors (income, prosperity, employment)
• Overall wealth will increase
• Education levels in the general population will improve
• The availability of oil and other energy supplies will worsen
• Quality of sanitation and water supplies will improve for humans
• Poverty and malnutrition will decline
• Waste disposal as a source of human disease spread will improve
• The availability of a pool of experts to detect and identify human infectious diseases will improve
• The available pool of experts in animal health will enlarge
G. Trade and market related factors
• The behaviour and structure of markets as affecting infections will improve
H. Transport and tourism
• More internal movement of people, food, other goods live animals and microorganisms
• Future levels of tourism to and from China will increase
• Levels of internal tourism will increase
I. Human activity and social pressures
• Sexual practices will become more risky
• There will be other changes in lifestyle increasing risk of infection
• Public tolerance of infection risk will decline and the willingness to change behaviours to reduce such risk will increase
• Public demands for greater levels of safety will increase
• Ecological awareness in the public will increase
• Media reporting as a driver of how governments react to infectious disease will increase
• Crowding in hospitals will increase
• Farmers and producers will become more aware of infection risk and biosecurity
• Media reporting on animal health issues will increase

Notable areas of consensus on expected trends in the drivers were as follows: There would probably be greater social cohesion and more transparency in Chinese governance with greater leadership shown by government on human health issues. Movements of animals around the country and internationally (meaning into and out of China) would be likely to increase and there would probably be more animals in urban areas. Similarly, there would most likely be more and larger scale internal human migrations and movements of people and more use of migrant labour within China. Tourism within, and to and from China was also considered likely to increase.

It was expected that because of growth and urbanisation additional stress would be placed on administrative systems which could threaten some surveillance for animal and human diseases. Conversely technological developments would provide more opportunities for surveillance, better detection of organisms and there would probably be more dissemination and sharing of information.

The production of waste from animals was considered likely to increase substantially and, with it, problems of waste disposal but there was no consensus that the same would happen for human waste. Genetic uniformity was expected to increase in crops and animals. In human healthcare, high technology medicine, the development of new medicines and vaccines would all increase. In the additional remarks the experts in the relevant areas said that in their opinion, this would take place because of technological change, growing number of older people and people with chronic conditions and increasing healthcare expectations in the population. However the experts were not sure whether or not China's population would age overall. It was felt that the use of hospitals and overcrowding in hospitals would probably increase, as would the use of antimicrobials in humans and in animals.

Overall individual wealth and levels of education were expected to rise, though there was no consensus on what would happen concerning income disparities. It was felt that sexual behaviour would change in ways that overall would increase the risk of acquiring and passing on sexually transmitted infections including HIV and other blood-borne viruses. However, it was also expected that the population would become less accepting of risks from infection and that there would be greater demands for safety, more ecological awareness of the importance of the environment and greater media reporting of health and environmental issues. Human sanitation was expected to improve but the availability of energy sources would probably worsen. The intellectual capacity of China was expected to rise with more experts in animal and human health.

Possible consequent trends in the infections

The application of the changes in the drivers (Table 1) against the matrices (Appendix) indicated that if the predicted trends materialised, and no countermeasures were applied, adverse changes (rises) in the rates of the following groups of infections would be expected:

Table 5

Analysis of expert opinions as to whether the selected drivers would improve or worsen in the coming two decades

Drivers	Expert 1	Expert 2	Expert 3	Expert 4	Consensus (or not)
A. GOVERNANCE AND SOCIAL COHESION					
1. Biosecurity governance (currently there is little biosecurity governance or regulation in China)	A	A	C	C	no consensus
2. Social cohesion	C	C	C	C	Social cohesion will increase
3. Illegal practices	D	C+	C	A	no consensus
4. International/Regional interactions	C	A&C	C+	C	International and regional interactions will increase
5. Lack of interaction between policy and regulatory agencies	D	C	A	A	no consensus
6. Inter-ministerial agencies: will these become more common?	C	D	C	D	no consensus
7. Problems across international agencies (sharing of information with international agencies)	C	D	D	C	no consensus
8. Openness with the public (government transparency)	C+	C+	C	C	Government transparency will increase
9. Marginalisation of some groups	D	C	A	A	no consensus
10. Political leadership	C+	C+	C	C	More political leadership relating to health issues
B. DEMOGRAPHY AND POPULATION CHANGE					
11. Immigration	D	D	A	D	no consensus
12. Urbanisation	D	A	A	D	no consensus
13. Migrant labour	D	A	A	A	More use of migrant labour
14. Overall population (specify detailed changes if possible)	B	D	D	D	no consensus
15. Elderly population	B	A	C	D	no consensus
16. Dietary and occupational changes	B	A	C	C&D	no consensus
17. Population movements	A	A	A	D	More population movement
18. Animal immigration	A	A+	D	A	More animal movements
19. Animal populations (increase or reduce)	B	A	A	D	no consensus

20. Urbanisation of animals	A	A+	A	A	More animals in urban areas
21. Animal population movements	A	A	A	A	More movements of animals
22. Movement of animals around the country	A	A	B	A	More movements of animals
C. CONFLICT					
23. Difficulties in maintaining administrative systems so loss of effective identification and surveillance systems	A	A	A+	D	Stress on administrative systems
24. Movement of refugees	C	B	B	D	no consensus
25. Internal conflict	A+	D	B	D	no consensus
26. Loss of effective identification and surveillance systems (for animals)	A or B	A	A	A	More stress on animal surveillance systems
27. Unrestricted movement of animals around the country	B or C	A	B	A	no consensus
D. TECHNOLOGY AND INNOVATION AND THEIR GOVERNANCE					
28. Impact of innovation on human disease identification and treatments	C+	C	C	C	More innovation in human disease diagnosis and treatment
29. Ability to control human infections and control strategies	C	C	C	C	Improved infection control strategies
30. Use of genetically modified crops	D	B	D	D	no consensus
31. Drug- and pesticide-resistant organisms	A	A	A+	C	More drug- or pesticide-resistant organisms
32. New surveillance opportunities (e.g. web-based and remote systems)	C	C	C	C	Increased opportunities for surveillance in animals
33. Information dissemination	C	C+	C	C	Better information dissemination
34. Faster identification of organisms	C	C+	C	C	Faster organism identification
35. Antiviral, antimicrobial and vaccine development	C	C	D	C	More antimicrobials and vaccines becoming available
36. Improved diagnostics	C	C	C	C	Improved diagnostics
37. Transplant surgery	B	D	D	B	no consensus
38. Other high technology medicine	C	C	C	C	More high technology medicine
39. Use of antimicrobials for humans	C	C	C	A	More use of antimicrobials in humans
40. Longer survival of patients with chronic diseases	D	B	A	B	no consensus
41. Impact of innovation on human disease, (identification and treatments)	C	C	C	C	More identification of human disease and more treatment
42. Ability to control infections, control strategies in animals	C	C	C	C	Greater ability to control animal infections
43. Drug- or pesticide-resistant strains in animals	A	A	A	A	More drug resistant strains in animals
44. New surveillance systems for animal diseases	C	C	A	C	More surveillance systems for animal diseases
45. Information dissemination concerning animals	C	C+	C	C	Better information dissemination concerning animals
46. Faster identification of infections in animals	C	C+	B	C	Faster identification of infection in animals
47. Use of antimicrobials in animals	A	C	C	C	More use of antimicrobials in animals
48. Improved diagnostics for diseases in animals	C	C	C	C	Better identification of infection in animals
E. AGRICULTURE AND LAND USE CHANGE					
49. Changes in animal husbandry methods	D	D	A	D	Future unclear
50. Greater genetic uniformity in crops and animals	A	A	A	D	Greater genetic uniformity in crops and animals
51. Intensive farming	D	A	D	B	no consensus
52. New crops	D	B	A	D	no consensus
53. More attention to economics	C+	C	A	C	More movements of animals for economic reasons
54. Proximity of different farming systems	D	D	A	D	Future unclear
55. Changing patterns of land use	A+ or D	C	A	D	no consensus
F. ECONOMIC FACTORS (INCOME PROSPERITY AND EMPLOYMENT)					
56. Overall wealth	C	D	C	C	Wealth increasing overall
57. Income disparity	C	A	D	C	no consensus

58. Education levels in the general population	B	C	C	C	Education levels will improve
59. Future oil and other energy supplies	A+	D	A	A	Availability of energy sources will worsen
60. Quality of sanitation and water supplies	C	C	C	A	Sanitation will improve
61. Background pollution levels	B	C	A+	A	no consensus
62. Poverty and malnutrition	C	C	C	C	Poverty will decline
63. Waste disposal	C	A	C	C	Waste disposal will improve
64. Pool of experts in human disease	A	C+	C	C	Numbers of experts in human health will increase
65. Unemployment	A	C	C	A	no consensus
66. Waste production and disposal (from animals)	A	A	D	C	no consensus
67. Pool of experts in animal health	C	C	C	C	Numbers of experts in animal health will increase
G. TRADE AND MARKET RELATED FACTORS					
68. Changing pattern of trade	C	D	A	C	no consensus
69. Behavior and structure of markets	C	C	A	C	Behaviour of markets will improve
70. Future diets and demands for exotic products	D	D	A	D	no consensus
71. Illegal trade	D	A	A	D	no consensus
72. Food preservation technology (please specify changes)	C	C	A	D	
73. Trade barriers	A	D	D	D	Future unclear
74. Changing patterns of trade in animals	C	A	D	A	no consensus
75. Illegal trade in animals	C	A	A	C	no consensus
76. Trade barriers for trade in animals	B	C	C	D	no consensus
H. TRANSPORT AND TOURISM					
77. International movement of people, foods, other goods, live animals, microorganisms	A	A	C	D	no consensus
78. Changes in the rates of internal movement of people, food, other goods, live animals, microorganisms	A	A	A	D or A	More movement of all
79. Future levels of international tourism a) from China, b) to China	A	A	A	D	Increased tourism to and from China
80. Internal tourism (inside China)	A	A	A	D or A	Increased internal tourism
81. Emergence of 'just in time' stockkeeping (shops and industry having low levels of stock and relying on new supplies arriving at the right time)	A	D	B	D	no consensus
82. Internal migration	A	A	A	D or A	no consensus
I. HUMAN ACTITIVY AND SOCIAL PRESSURES					
83. Demands for more healthy food	B	B	C	C	no consensus
84. Demands for more sustainable production	D	D	D	C	no consensus
85. Changes in sexual practices	A	A	A+	A	More risky sexual behaviours
86. Changing lifestyles	A	A	D	A	Changes in lifestyles making more liable to risk of infections
87. Public perceptions of and acceptance of risk	C	C+	C	C	Less public tolerance of risk
88. Demands for greater levels of safety	C	C	C	C	More public demands for more safety
89. Demands for lower levels of pollution	A	C	C	D	no consensus
90. Ecological awareness	D	C	C	C	More awareness of ecological factors
91. Willingness to change	C	D	D	C	no consensus
92. Media reporting on human diseases	C	D	C	C	Greater media reporting
93. Overcrowding in hospitals	A	A	A	A	More overcrowding in hospitals
94. Farmers and producers perception of risk and biosecurity	C or D	C	C	C	Farmers more aware of risk and biosecurity issues
95. Willingness to change farming practices	D	D	D	C	no consensus
96. Media reporting on animal health issues	C	C	D	C	More media reporting on animal health issues

Legend
A = Intensify (getting worse) B = Stay the same C = Become less intensive (getting better) D = Future unclear
A+ or C+ were used if the expert said that large change was anticipated.
Consensus was reached if at least three of the four experts agreed.

- Animal infections (e.g. foot and mouth disease, avian influenza and classical swine fever) as a result of animal movements;
- Infections acquired as a result of receiving healthcare (nosocomial or healthcare-associated infections);
- Infections caused by drug-resistant organisms in animals and humans;
- Human sexually transmitted infections, including HIV;
- Human blood-borne viral infections associated with high-technology care (such as hepatitis B and C);
- Food-borne infections affecting humans and zoonoses in humans and animals including emerging infections;
- Imported and exotic infections.

Discussion and lessons learnt

Historically China has been a potent source of infections that have come to affect or threaten Europe. The influenza pandemics of 1957 and 1968, the avian influenza A(H5N1) ('bird flu') and severe acute respiratory syndrome (SARS) all appeared first in China [6-7]. The Foresight China Project has identified a number of likely future trends for drivers of infectious diseases in China that could potentially lead to increases in rates of healthcare-associated infections, drug-resistant organisms, sexually transmitted infections and zoonoses as well as other novel infections and variants of previously identified infections. The results identifying the probable changes in drivers in China can be compared to those obtained in the main Foresight project for the UK and Africa even if only limited predictions can be made as to their impact on actual diseases. These comparisons reveal some broad similarities in the trends in the drivers thus recognising the universality of some international changes [5].

Lessons from this application

The China Project also revealed a number of methodological issues that need addressing. The selection of drivers used in this study and the relationship between the drivers and infections were probably not sufficiently evidence-based and need to be supported by a literature review. The questions put to the experts were probably too open-ended and there were difficulties in the analysis of their additional comments. Because the subject of the project was known, there were difficulties in getting the experts to focus on the trends in the drivers without considering the trends in the infections that might result from these changes. Also, it was notable how the recent Chinese experience with SARS in 2003 influenced some of the expert opinions which tended to hark back to that event. The number of experts (only four per family of drivers) was perhaps too limited and for some of the areas it was felt that if the experts could have met together rather than individually, a more useful consensus would have been achieved.

It is important not to over-interpret the suggested trends indicated here. Aside from this being a limited initial application, there are difficulties in drawing any conclusions from this form of qualitative predictions. What should be concluded when two drivers are running contrary to each other? For example, it was suggested that sexual behaviours will become more risky while at the same time the public will generally become more aware of risks. An additional point is whether such a unitary approach can be undertaken for countries that are as large and diverse as China. Trends that might apply in the richer east and semi-tropical south of China might be quite different in the less well resourced western provinces and the temperate and continental north of China. In a way these considerations do not matter as long as the predictions are not seen as what will certainly happen. What are being suggested are the more likely changes in disease risks and possible threats that the authorities should be aware of and prepare for. These changes are not inevitable as future trends also depend on countermeasures deployed either against the infections or to offset the underlying drivers. The real conclusion is to suggest priorities for surveillance and development of countermeasures. The results suggest these priorities should include animal infections associated with animal movements, and, in humans, zoonoses, sexually transmitted infections, healthcare-associated infections and antimicrobial resistance. Equally, the authorities could consider whether to take a precautionary approach and implementation of countermeasures at an early stage, for example by giving more priority to hygiene in hospitals and rational approaches to antimicrobial prescribing. However, historical events including developments like SARS and highly pathogenic avian influenza in China indicate that to some extent future events in infectious diseases can never be entirely anticipated [7,10]. Hence it is crucial to establish basic surveillance and response mechanisms in a strong modern public health framework that can detect and respond to whatever threats should appear in the future.

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Appendix. Examples from the two matrices with the presumed relationship between animal and human infections and the drivers (full matrices are available on application to the corresponding author).

Available in pdf:

http://www.eurosurveillance.org/public/public_pdf/Foresight_China_Appendix.pdf

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