

Foresight

Infectious Diseases: preparing for the future

OFFICE OF SCIENCE AND INNOVATION

T13: A novel approach to anticipating future risk of infectious disease trends in China: methodology and results

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not represent the policy of any Government or organisation.*

Summary

The study devised a simple but novel methodology for identifying likely future trends in families of infectious diseases. This was then applied in China. It used a model of infectious disease drivers devised for the Foresight Project.

Matrices were derived from disease experts to identify the likely relationship of single diseases or families of diseases to nine families of societal drivers. The likely trends in those drivers were then identified from 36 independent specialists in those areas. Finally the trends in the drivers are applied back to the matrices to identify likely trends in infectious diseases in animals and humans, in this case in China.

This demonstrated a number of areas where the Chinese authorities are likely to experience difficulties in the future, such as rising numbers of hospital-acquired infections, zoonoses and sexually transmitted infections (including HIV/AIDS). It is suggested that the method can be used to determine priorities for surveillance and for countermeasures including measures against underlying causes, where these are possible.

Background

The work is part of the Foresight Project, Infectious Diseases: preparing for the future (UK Office of Science and Innovation). The aim of the project is to look ahead 10-25 years and to produce a challenging and long-term vision for the detection and identification of infectious diseases in plants, animals and humans. This vision takes account of: the evolving risk of and vulnerabilities to diseases; changing user requirements for detection and identification; and cutting edge science. The project aims to inform policy at a national and international level by showing how these threats to health can be anticipated, detected, prevented and controlled. One of the major areas of analysis involves risk evaluation and has been co-ordinated by Professor Joyce Tait of the University of Edinburgh.¹ This work has looked at three distinct geographical areas: the UK, sub-Saharan Africa and China. This paper describes the methodology behind the China work, which was developed during the first half of the 2005, especially during a workshop in London in March 2005. This and all other parts of the work were supported by a grant from the Department of Trade and Industry as well as by the provision of time by the employing bodies of the above-named authors.

Objectives of the China Programme of Work:

To devise and develop priority lists of human and animal infections in China, that will assist in the prioritisation of infections singly or in groups for surveillance and control. The main criteria were selected according to public health principles and current policy priorities of the Government of China. That is, they reflect the expected impact of diseases in China on:

¹ This and the other three Work Packages are summarised in Annex 1

- a) human health
- b) economics and development
- c) social stability

The Scientific Problem

*"It is very difficult to make predictions, especially about the future"*²

A variety of methods are commonly used to predict future trends in infectious diseases. These include short-term predictions (extending recent trends into the future) and simple or complex transmission modelling (mathematical techniques attempting to anticipate the future incidence of human infections).¹⁻
³ These approaches have considerable value in making quantitative predictions. However, they suffer from some major drawbacks.

They can, by definition, only operate in the short-term (maximum five years) since, beyond that time, either the current conditions can no longer be expected to apply (*predictions*) or the variabilities tend to become imponderable and confidence intervals expand massively (*modelling*).^{4,5} This is problematic when programmes such as Foresight seek to look well beyond five years.

Also, these approaches usually only cover specific pathogens such as HIV/AIDS, measles, CJD etc., rather than groups of infections. They are, therefore, especially vulnerable to the emergence of unknown pathogens.¹⁻⁵ Finally, they often fail to take into account the trends in the drivers for infectious diseases, which is the approach favoured by the Foresight Project.⁶

General Methodology

To overcome the above limitations, the China Programme of Work identified a series of families of factors - '*drivers*' - which included the following:

- Factors that affect the source of the risks (e.g. changes in animal husbandry)
- Factors affecting how diseases are spread (e.g. changes in the movement of people and changes in institutional structures)
- Factors affecting the assets at risk (crops, business, people, animals).
- Factors that are likely to be influencing vulnerabilities
- Priorities and requirements for surveillance to detect anticipated risks and changes in risks
- Priorities and opportunities for control of risks and diseases

² Yogi Berra - Sage and Baseball Player

Specific Methodology

Based on the model developed by Professor Tait and others for the overall Work Programme A (Annex 1) in order to identify drivers of current and future trends in the priority animal and human diseases in China, the Project team devised and populated matrices of drivers of current and future trends for priority families of animal and human infectious diseases (Annex 2). For example, recognised drivers for increases in sexually transmitted infections, including HIV/AIDS, would include adverse changes in sexual behaviours, increasing migrant labour, decline in educational levels, falls in the earning capacity of women. The opposite trends would logically tend to be protective and would be expected to lead to decreases in sexually transmitted infections, including HIV/AIDS.⁶

This left the problem of how to identify the likely trends in drivers of infections and, specifically, how to identify likely important trends in the drivers of current and future levels of priority animal and human diseases in China. Following approval from the Ethics Committee of the Chinese Academy of Medical Sciences, Peking Union Medical College, this was achieved through undertaking a review of expert views of 36 relevant Chinese specialists in the drivers who were identified by the Chinese collaborators (Annex 3 & 4). These were, generally, chosen because they were specialists in one or more of the drivers. They did not necessarily have to be specialists in infectious diseases.

Their views and opinions were derived from face-to-face interviews undertaken by a small team of postgraduate students trained by the project manager. Analysis was undertaken in China in November 2005 to arrive at the trends in drivers which were then applied back to the matrices to identify priority groups in human and animal diseases that are likely to increase or decrease. Hence, gaps and trends in vulnerabilities for human and animal infectious diseases were identified. These would also be areas where countermeasures needed to be developed or mitigations put in place.³

Preliminary Results – Drivers

The attached Excel spreadsheets show the matrices indicating the drivers identified as being of importance for each family of, or single, animal or human infectious disease(s). Areas of strong consensus on projected trends by the 36 experts were:

- There would be greater movement of animals around the country and internationally (into and out of China).
- There would be more, bigger internal migrations of people.
- Tourism within, from and to China will increase.

³ The work paid particular attention to emerging and re-emerging animal and zoonotic human infections which it is anticipated will contribute the bulk of emerging infections

- The production of waste, including that from animals, would increase substantially and, with it, problems of waste disposal.
- Internal movements of animals, people, foods and other animal products would increase and, with this, rates of movement of microorganisms.
- Genetic uniformity would increase in crops and animals.
- High technology medicine, transplants and the use of antimicrobials in secondary care would increase substantially, because of technological change, an ageing population and increasing health expectations.
- Use of hospitals and overcrowding in hospitals would increase, as would the use of antimicrobials and therefore, the risk of healthcare-associated infections and antimicrobial-resistant organisms.
- There would be many more opportunities for sophisticated surveillance through technological developments.
- Overall wealth and levels of education would rise, though data on income disparity need further analysis.
- Sexual lifestyles are changing in ways that overall increase the risk of acquiring and passing on sexually transmitted infections including HIV/AIDS and the bloodborne viruses.
- Popular acceptance of risks from infection would decline significantly, and there would be greater demands for safety

Preliminary Results - Priority infections

A preliminary application of the above changes in the drivers would suggest that if these trends materialise, *and no countermeasures are applied*, adverse changes (rises) in the rates of the following groups of infections can be expected:

- infections acquired as a result of receiving healthcare (nosocomial infections)
- antimicrobially resistant organisms
- sexually transmitted infections, including HIV/AIDS.
- blood-borne viruses associated with high-technology care (hepatitis B and C)
- some food-borne infections and zoonoses in general
- imported and exotic infections.

Conclusions

This innovative work has identified a number of likely trends for infectious diseases in China in the future, with potential for increases in healthcare-associated infections, antimicrobial-resistant organisms, sexually transmitted infections and zoonoses. These increases are not inevitable as future trends

also depend on any countermeasures that are deployed either against the infections or to offset the underlying drivers, Finally, this work indicates some of the areas that surveillance should concentrate on. However historical events including developments such as SARS and highly pathogenic avian influenza in China⁷ indicate that to some extent future events in infectious diseases can never be entirely anticipated. Therefore it is also crucial to establish basic surveillance and response mechanisms in a strong modern public health framework that can detect and respond to whatever appears.

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Advisors

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Prof Joyce Tait and **Dr Laura Meagher**, ESRC Innogen Centre, University of Edinburgh were responsible for providing advice on selection of questions for the 'Chinese Expert Review Protocol' (see below) and linkage with the rest of Work Programme A (Annex 1).

Professor Dirk Pfeiffer, Royal Veterinary College, North Mimms, Hatfield, Herts, UK, provided expert advice on animal health issues.⁴

Annex 1. The Foresight project on the detection and identification of infectious diseases

Key parts of the project

- ‘Risk evaluation’: drawing on the best available evidence, review and compare future risks from infectious diseases using a common set of metrics; identify the factors driving changes in risk; assess how the size and nature of risks are evolving and indicate the range of plausible future patterns of risk.
- ‘User contexts’: in the light of the emerging pattern of risks identified, assess future user contexts and requirements for detection and identification of infectious diseases – note: these will also need to take account of the early findings on potential new opportunities offered by developments in the science of detection and identification (as identified in work package C below).
- ‘Science reviews’: review cutting edge science and technology that is potentially relevant to detection and identification. Assess the extent to which it will meet and influence future requirements. The work will also explore the potential for step changes in capability. This work will be informed by the emerging findings of work packages A and B, and will in turn inform the subsequent work in packages B and D.
- ‘Options appraisal: consider the implications of possible gaps between future science capabilities and user contexts and requirements in order to inform decision making in strategy at national and international levels. Note: the detailed structure of work packages B, C and D has not yet been decided.

Each of the above work packages is closely linked to the others, but will be performed by different multidisciplinary teams of experts and stakeholders.

2. Drivers considered

2.1 Governance and social cohesion

- Governance of technology (drugs and pesticides)
- Global social equity
- Bio-security legislation
- Social cohesion as an enabler or constraint on identification and control of infectious diseases
- Illegal practices (poaching and 'white van man'); illegal 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
- Problems across international agencies, particularly barriers to the sharing of data

2.2 Demography and population change

- Immigration
- Urbanisation
- Ageing population
- Gender imbalance
- 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)

2.3 Technology and innovation and their governance

- Impact of genomics-related 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)
- New, faster identification infrastructures
- Development of new vaccines
- Future availability of anti-virals as a control option (will they be better and/or cheaper)
- Improved diagnostics, leading to more accurate, less costly and more rapid detection of diseases
- 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)

2.4 Conflict

- Loss of effective identification and surveillance systems
- Movement of refugees spreading diseases
- Domestic immigration ('floating populations')
- Bio-terrorism – *innovative* (using biotechnology to create new diseases) or *opportunistic* (hastening the spread of existing or emerging diseases) affecting animals, plants or humans

2.5 Agriculture and land use change

- Changes in animal husbandry methods, e.g. intensive rearing methods or closer mixing 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 F&M
- More frequent proximity of different farming systems
- Changing patterns of land use due to new disease treatments (e.g. treatments for river blindness in Africa leading to movement of agriculture into new areas)

2.6 Economic factors (income, prosperity, employment)

- Overall wealth (e.g. GDP)
- Education levels in the general population
- Future oil supplies
- Quality of sanitation and water supplies
- Background pollution levels affecting the natural immunity of plants, animals and humans
- Poverty and malnutrition
- Waste disposal as a source of disease spread
- The availability of a pool of experts to detect and identify infectious diseases

2.7 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 trade (e.g. bush-meat)
- Food preservation technology
- The misuse of disease surveillance systems as trade barriers

2.8 Transport and tourism

- International movement of drug or vaccine-resistant strains of organisms
- Future levels of tourism
- Changes in the rate of movement of diseases; compressed time scales

2.9 Human activity and social pressures

- Demands for more healthy food and more 'sustainable' production systems
- Changes in sexual practices
- Changing lifestyles – consumerist, individualist, communitarian
- Public perceptions of risk and willingness to change behaviours
- Media reporting as a driver of how governments react to disease

3. Matrix Interplay

The interplay between (a) drivers, (b) sources and (c) pathways are illustrated in figure 1 below.

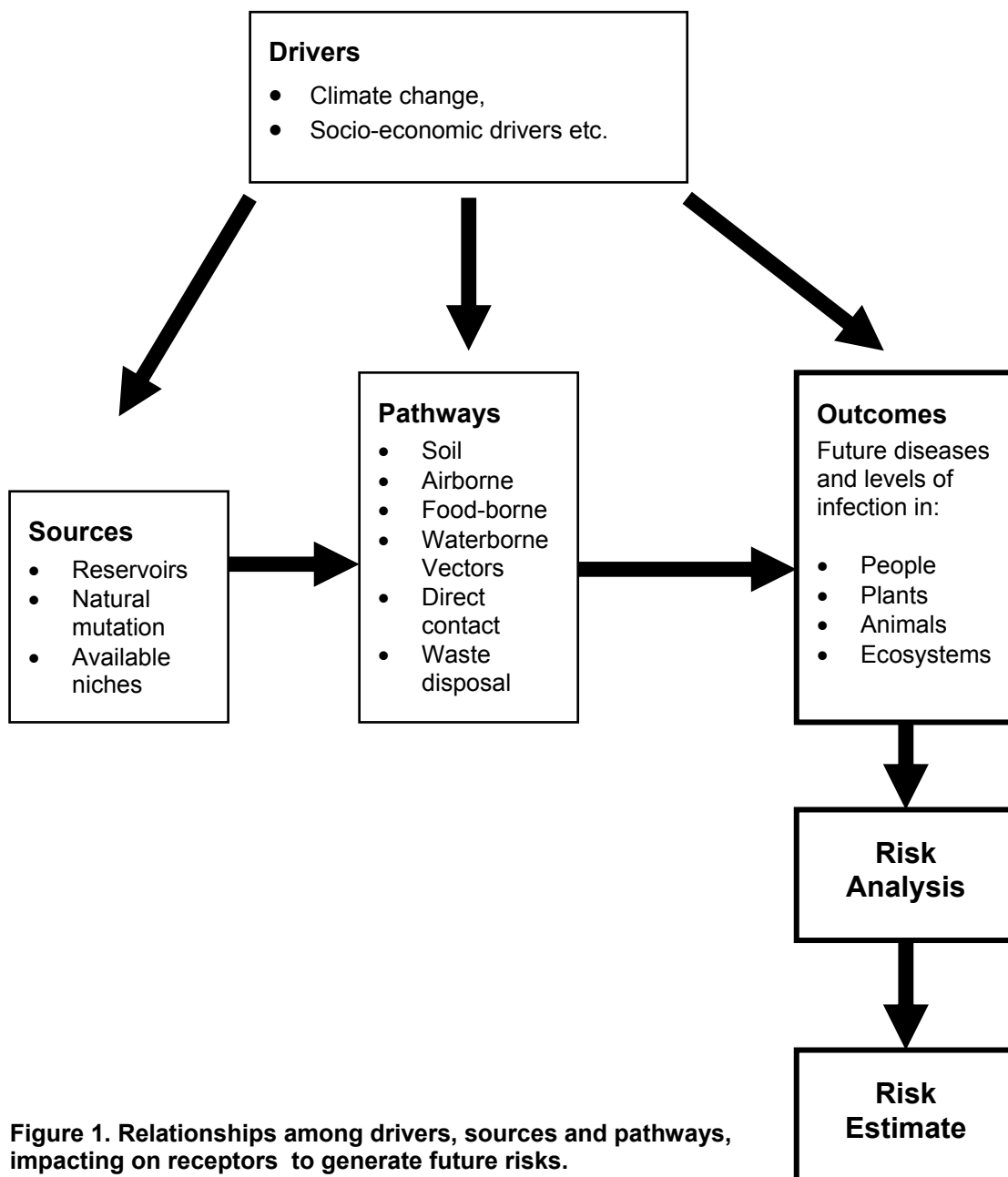
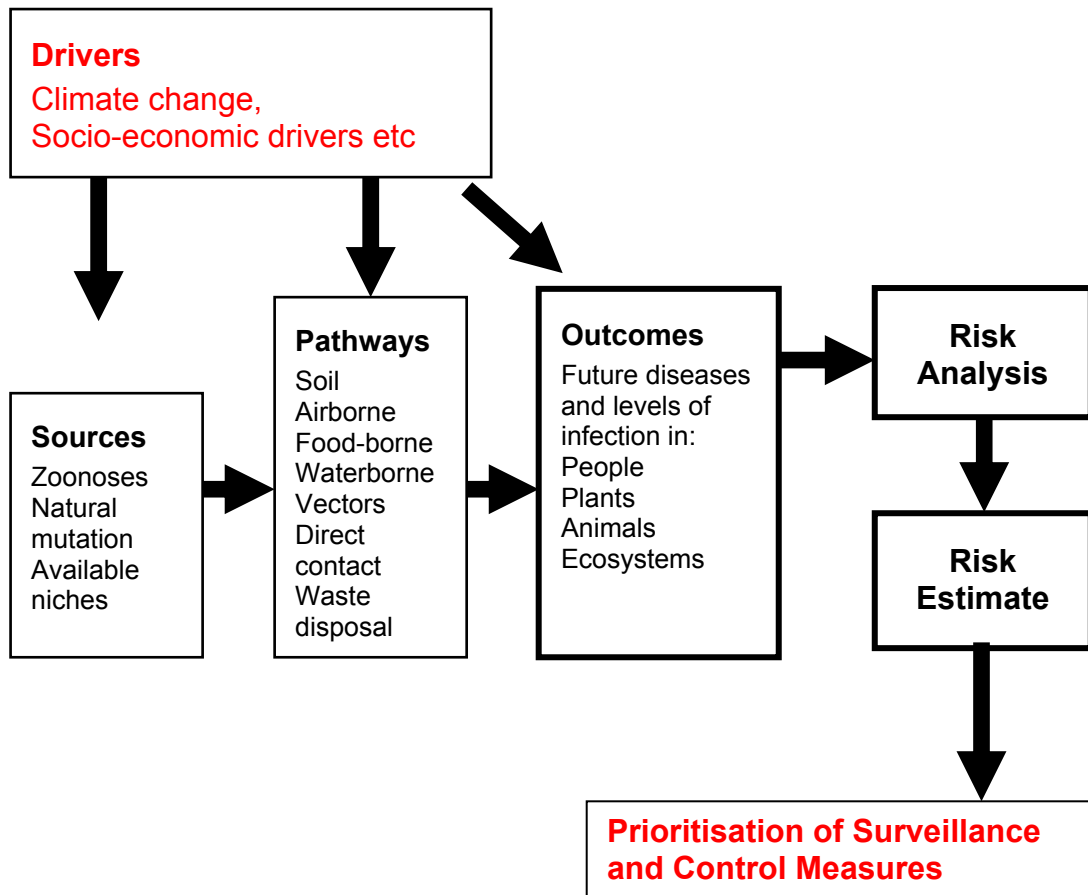


Figure 1. Relationships among drivers, sources and pathways, impacting on receptors to generate future risks.

Figure 1. Basic Risk Model for Infectious Disease Risks



Annex 2. Design of Matrices

A Human Diseases Considered

The Diseases (the rows)

Antimicrobial Resistance
Bloodborne infections Hepatitis B & C
Gastrointestinal Disease (Food Poisoning)
Healthcare associated infections
HIV
Other Sexually Transmitted Diseases
Malaria
Nosocomial infections
Respiratory – Acute Influenza (seasonal and pandemic) / SARS
Parasitic Diseases (Shistosomiasis etc.)
Tuberculosis
Vaccine preventable diseases (childhood)
Zoonoses (with B)
Novel infections

The Drivers (Categories⁵ –(The Columns)

<i>Biological (Infections) e.g. R₀, Infectious Period, Incubation Period, Incubation Period, Asymptomatic Transmitters, Detectability</i>
<i>Sources</i>
<i>Pathways</i>
<i>Control Factors and Tractability</i>
<i>Governance and social cohesion:</i>
<i>Demography and population change</i>
<i>Technology and innovation and their governance</i>
<i>Conflict</i>
<i>Agriculture and land use change</i>
<i>Economic factors (income, prosperity, employment)</i>
<i>Trade and market related factors</i>
<i>Transport and tourism</i>
<i>Human activity and social pressures</i>

⁵ more detailed categories were developed under each as an Excel Spread Sheet (see Results)

B. Animal Infection Groupings

Animal Only

Foot-and-mouth disease

Classical swine fever

Animal / Human

Highly pathogenic avian influenza (poultry and multi-species)

SARS (as a model for a novel infectious disease)

Bovine Spongiform Encephalitis

The Drivers

Biological (Infections) e.g. R_0 , Infectious Period, Incubation Period, Incubation Period, Asymptomatic Transmitters, Detectability
Sources
Pathways
Control Factors and Tractability
Governance and social cohesion:
Demography and population change
Technology and innovation and their governance
Conflict
Agriculture and land use change
Economic factors (income, prosperity, employment)
Trade and market related factors
Transport and tourism
Human activity and social pressures

Annex 3 - Translation of Letter sent to National Experts

Dear ,

I am the project interviewer for the China Foresight Project – Expert Opinion Review. The project is a part of the *Foresight Programme* (Department of Trade and Industry, UK and PUMC) on future risks *from* infectious diseases in humans, animals and plants. The aim of this sub-project is: *To identify likely important trends in the drivers of current and future levels of priority animal and human diseases in China through undertaking a review of expert views of relevant Chinese specialists.*

Principle Investigators are Dr. *Huang Jianshi, Professor of Epidemiology and Assistant President, Chinese Academy of Medical Sciences, Peking Union Medical College; Dr. Yang Gonghuan, National Centre for Public Health Surveillance and Information Services, Chinese Centre for Disease Control & Chinese Academy of Medical Sciences, Peking Union Medical College.*

You are an expert in this field. We sincerely invite you to offer your opinions.

Thank you for your acceptance for the interview.

If there are areas that are outside your expertise you are encouraged to check with a colleague of your choice. If you agree, we would like to follow up by telephone later for the opinion.

If there are any other trends you feel important for categories that we have not mentioned you are welcome to express your opinions.

Council for Bioethics, Institute of basic Medical Sciences, Chinese Academy of Medical Sciences, Peking Union Medical College (OUR FEDERAL WIDE ASSURANCES NUMBER: FWA00005023) has reviewed the proposed use of human subjects in the project 'China Foresight Project – Expert Opinion Review', in which human subjects will be interviewed. The right and welfare of the subject are adequately protected and the subjects will not undergo any harm.

Thank you for your assistance.

China Foresight Project – Expert Opinion Review
October 2005

Annex 4 Chinese Experts involved in A EXPERTS

Number	TITLE	UNIT	SPECIALISM
A Governance and social cohesion			
1	Director	Department of International Cooperation, Ministry of Health	Public Health
2	Deputy President	Department of International Cooperation, Ministry of Health	Public Health
3	Deputy President	Department of International Cooperation, Ministry of Health	Health Management
4	Director	Department of Disease Prevention & Control, Ministry of Health	Health Management
B. Demography and population change			
5	Chief Scientist Professor	National Centre for Public Health Surveillance and Information Services, CDC	Public Health Surveillance
6	Director Professor	Beijing University	Demography
7	Associate Professor	National CDC	Epidemiology
8	Director Professor	Department of Epidemiology, PUMC	AIDS
C. Conflict			
9	Professor	Department of Epidemiology, PUMC	Hepatic
10	Director Professor	Department of Infectious Diseases, PUMCH	Infectious Diseases
11	Professor	Beijing Center for Disease Prevention & Control	Epidemiology
12	Associate Professor	Dean's Office PUMC	Microorganism

D. Technology and innovation and their governance			
13	Deputy President, Professor, Senior Doctor	Beijing You'an Hospital	Infectious Diseases
14	Professor	Department of Epidemiology, PUMC	Epidemiology
15	Associate Professor	Department of biochemistry, PUMC	Biochemistry
16	Associate Professor	Beijing Capital Medical University	Social Medicine
E. Agriculture and land use change			
17	Professor	Research Institute, China Agricultural Academy	Plant Protection
18	Associate Professor	Ministry of Agriculture Fed Industry Center	Nutrition
19	Professor	Institute of Zoology Chinese Academy of Sciences	Genetics
20	Professor	Institute of Agricultural Economics and Development Chinese Academy of Agricultural Sciences	Agricultural Economy and Management
F <input type="checkbox"/> Economic factors (income, prosperity, employment			
21	Manager	Welltech Health Management Co.LTD	Health Management
22	Director	Sinochem Corporation	Economic Management
23	Professor	State-owned Assets Research Centre of the State Council	Economic
24	Associate Professor	Department of Epidemiology, PUMC	Epidemiology
G. Trade and market related factors			
25	Vice	Beijing Dianji Technology	Commerce

	president Visiting Professor	LTD. School of Management, Beijing University of Posts and Telecommunications	
26	Vice President	China Ocean Shipping(Group) Company	Commerce
27	Director, Senior Doctor	Emergency Office, Beijing Municipal Health Bureau	Health Emergence Management
28	Professor	Beijing University	Commerce
H. Transport and tourism			
29	Associate Director	The Center for Tourism Research, The Chinese Academy of Social Sciences	English Tourism
30	Associate Professor	Development Research Center of State Council	Tourism
31	Professor	School of Management, Beijing International Studies University	Tourism Management
32	Professor	School of Tourism, Beijing Union University	Tourism
I Human activity and social pressures			
33	Associate Senior Doctor	Emergency Department, PUMCH	Emergence Medicine
34	Professor	Department of Social Sciences, PUMC	Medicine Ethics
35	Professor	School of Public Health, Peking University Health Science Center	Epidemiology
36	Associate Professor	School of Public Health, Peking University Health Science Centre	Epidemiology

All the reports and papers produced within the Foresight project 'Infectious Diseases: preparing for the future,' may be downloaded from the Foresight website (www.foresight.gov.uk). Requests for hard copies may also be made through this website.

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