Virus Jumping:

How Viruses Move from One Species to Another

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Viruses

Influenza A

SARS coronavirus

SARS-CoV
SARS-Coronavirus (SARS-CoV)

- 2002-2003, Guangdong province, China
- Atypical viral pneumonia
- >8000 cases, >800 dead. ~10% mortality
- SARS-like viruses in palm civet's, raccoon dogs, bats
- Antisera found in blood from before epidemic

Zoonosis
Because the three patients were received by the same hospital within one week, it was difficult to identify the exact transmission path for individual patients. Later, viral genomic sequencing data (Chinese 2004) indicated that only one kind of viral genotype was observed in the secondary and tertiary infections of the HZS-2 Hospital and other related hospitals (see below). Therefore, the following epidemiological facts are critical for chasing the origin of this viral lineage.

The onset date for SGQ was 8 January 2003 and he was transferred from a Shunde local hospital to the HZS-2 Hospital in Guangzhou on 18 January 2003. He infected his brother (SQS, onset date, 18 January 2003) and several hospital staff in a Shunde hospital (maybe with other atypical pneumonia patients in that hospital). He was confined to the ICU of the HZS-2 Hospital until death on 31 January 2003 and probably infected one ICU staff member and a patient.

The onset date for SQS was 18 January 2003. First, he was treated in a local hospital of Shunde and then transferred to the HZS-2 Hospital on 24 January, where he came into contact with many hospital staff members as well as other patients in the ward specialized for respiratory infectious diseases. He had relatively mild symptoms. He recovered and was released from the hospital on 16 February 2003.

The third patient, ZZF, is a 44-year-old businessman who specialized in the wholesale of fish. His onset date was 22 January 2003. First, he visited a local clinic on 26 January 2003 without notable infectious disease symptoms and was then admitted to the HZS-2 Hospital on 30 January 2003. Besides other atypical pneumonia syndromes, he began to have diarrhoea on 1 February and was transferred to the HZS-3 Hospital. During his less than 48 h stay in the HZS-2 Hospital, he infected more than 30 hospital staff members and patients, and two of them finally died. Later, within an 8-day stay in the HZS-3 Hospital, he infected 21 hospital staff members and one of them died. He was further transferred to Hospital GZS-8 on 8 February 2003. He probably infected three hospital staff members there, while he had an intubation procedure for ventilatory support. Apparently, he did not cause further hospital infections in Hospital GZS-8. He began to recover on 10 February 2003 and was released from the hospital on 21 March 2003.

ZZF infected 23 relatives, visiting friends and workers with close contacts. Two of them finally died. Tertiary and quaternary infections did occur in the HZS-2 Hospital but not in the HZS-3 Hospital, which is clearly due to better isolation control. The infection in the Ward L2 of Hospital GZS-8 seems to have been the beginning of Hotel M outbreak.
Zoonoses: 61-70% of all modern EIDs
How do viruses jump?

or

What causes interspecies transmission
Coronaviruses

- +ssRNA viruses
- Ancestral CoV – Insectivorous Bats
- Many spillovers ‘jumps’
Coronavirus Host Jumps

Coronavirus Host Jumps

Coronaviruses jump hosts by binding different cells.
Clues to the pandemic were in the anatomy

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Coronavirus S

VERY large
~200 kDa
~200 Å long X 70 Å wide

Very variable
Mutations affect
receptor binding specificity
tissue tropism
host range
triggering of conformational changes
membrane fusion activity
pH of fusion, site of entry
antigenicity
Clues to the pandemic were in the anatomy

Non-silent nucleotide changes in S genes of human and animal SARS-CoV isolates

| Virus  | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| SZ16   | C | A | T | T | C | A | T | T | C | A | G | G | G | G | C | G | C | G | T | G | A | T | C | C | T | C | G | T | G | G | C | G | C | T | C |
| SZ1    | C | A | T | T | C | A | T | T | C | A | G | G | G | G | C | G | G | T | G | T | T | A | T | C | C | T | T | G | T | G | G | C | G | T | T |
| GZ01   | C | A | T | T | C | A | C | C | C | C | A | G | G | T | G | T | C | A | G | T | T | T | T | T | C | C | A | C | G | T | A | C | G | C | C | G | C |
| GZ60   | C | C | C | C | C | C | A | G | G | T | T | T | T | C | C | A | C | G | T | T | T | T | T | T | C | C | A | C | G | T | A | C | G | C | C | G | C |
| GZ90   | T | A | T | T | C | A | T | T | C | A | G | G | G | G | G | G | A | A | T | T | G | T | T | T | T | T | T | C | C | A | C | G | C | T | C |
| CUBK-W1| C | A | T | T | C | A | T | T | C | A | G | G | G | G | C | G | A | A | T | T | G | T | T | T | T | T | T | C | C | A | C | T | C | A | C | G | T |
| HKU-36871| C | A | T | T | C | A | T | T | C | A | G | G | G | G | C | G | A | A | T | T | G | T | T | T | T | T | T | C | C | A | C | T | C | A | C | G | T |
| HKU-39848| C | A | T | T | C | C | C | C | C | C | C | C | C | C | G | A | G | A | T | T | G | T | T | T | T | T | T | C | C | A | C | T | C | A | C | G | T |
| HKU-66078| C | A | T | T | C | C | C | C | C | C | C | C | C | C | C | G | A | G | A | T | T | G | T | T | T | T | T | C | C | A | C | T | C | A | C | G | T |
| HKU-65806| C | A | T | T | C | C | C | C | C | C | C | C | C | C | C | C | G | A | G | A | T | T | G | T | T | T | T | C | C | A | C | T | C | A | C | G | T |
| Urban  | C | A | T | T | C | C | C | C | C | C | C | C | C | C | C | C | C | G | A | G | A | T | T | G | T | T | T | C | C | A | C | T | C | A | C | G | T |
| Tor2   | C | A | T | T | C | C | C | C | C | C | C | C | C | C | C | C | C | C | G | A | G | A | T | T | G | T | T | T | T | T | T | T | T | C | C | A | C | T | C | A | C | G | T |

Interspecies Transmission?
A quasispecies is a group of viruses related by a similar mutation or mutations, competing within a highly mutagenic environment.

Moving to a new species = Selective Pressure

Lauring and Andino. PLOS Pathogens 6(7):e1001005 (2010)
Small mutations over time can cause big changes!

SARS adapted to humans

SARS unable to infect humans
HUMAN VIRUSES HAVE ANIMAL ORIGINS

(Wolfe, Panosian and Diamond, 2007, Nature)
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Interspecies movement!

Feline parvovirus

Canine coronavirus
Global trends in emerging infectious diseases

Kate E. Jones¹, Nikkita G. Patel², Marc A. Levy³, Adam Storeygard³†, Deborah Balk³†, John L. Gittleman⁴ & Peter Daszak²

Figure 1 | Number of EID events per decade. EID events (defined as the temporal origin of an EID, represented by the original case or cluster of cases that represents a disease emerging in the human population—see Methods) are plotted with respect to a, pathogen type, b, transmission type, c, drug resistance and d, transmission mode (see keys for details).
More interaction = more zoonoses?

- Why are we seeing more zoonoses now than ever before?
- Are there hot spots for zoonotic events?
Where is the Risk?
So what do we know now?

“EID events are dominated by zoonoses (60.3% of EIDs): the majority of these (71.8%) originate in wildlife (for example, severe acute respiratory virus, Ebola virus), and are increasing significantly over time.”

“EID origins are significantly correlated with socio-economic, environmental and ecological factors...”

Substantial number of zoonoses come from Bats.
Why Bats?

- Flying mammal
- Ubiquitous
- Long-lived and High survivability
- 20% of all known mammal species
- Close association with humans
- Highly active immune system

Excellent Reservoir Host

Coronavirus Host Jumps

Virus Jumping in Alaska?
Adaptations happen where populations mix
Alaskan Bats – *Myotis lucifugus*

Photo: Gabor Csorba, HNHM
What does this mean in AK?

- Viral distribution in host species populations.
  - Insectivorous Bat populations
Samples from all across Alaska are being analyzed.
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Questions

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