Surveillance:
To surveil or not to surveil?

Nick Honhold

- Purpose of surveillance
  - Detection of a new outbreak (Find it Fast)
  - Ongoing outbreak control (really same as above)
  - Estimating how much disease there is

- Classic veterinary division of surveillance types
  - Passive
  - Active

- Specific types of active surveillance
  - Participatory
  - Targeted

- Surveillance is a test
- It has the same attributes of sensitivity and specificity etc. as a laboratory bench test
- It is important to know what these attributes are for any test including surveillance systems
- Surveillance is mostly used as a screening test to find suspect cases
- In this situation, sensitivity is the most important attribute. You have to find the disease.
- False positives are better than false negatives?
- No surveillance system is 100% sensitive at detecting a single event

Passive surveillance

- Unfashionable
- “Passive “ is seen as not good enough
- Pressure from medical profession during H5N1

- Depends on reporting of suspect cases by farmer/animal health worker to veterinary authorities
- Never perfect
- But is how almost all outbreaks are found

Passive surveillance: How good should it be?

How sensitive does passive surveillance have to be?
How many events will occur before an outbreak is detected?

		Sensitivity of passive surveillance for detecting a single event								
		90%	80%	75%	70%	67%	60%	50%	40%	33%
Level of confidence of outbreak detection	90%	1	2	2	2	3	3	4	5	6
	95%	2	2	3	3	3	4	5	6	8
	99%	2	3	4	4	5	5	7	9	12
	99.9%	3	5	5	6	6	8	10	13	17

Somewhat arbitrary, but a figure of 60 - 70% sensitivity would seem necessary

Scanning active surveillance

- Purposive visits to detect a particular disease or syndrome
- Can be resource intensive
- 40,000 villages, 1,000 vets, 1 vet for 40 villages.
- Each vet has many duties
- Each visit takes at least half a day, maybe more
- 20 working days per month
- How many visits per year are possible?

Probability of detection of a single outbreak

Depends on the frequency of visits and the duration of signs

No of visits per year	0.4	0.5	1	2	3	4	6	12	26	52
Daily probability of a visit	0.1%	0.1%	0.3%	0.5%	0.8%	1.1%	1.6%	3.3%	7.1%	14.2%

No of visits per year	0.4	0.5	1	2	3	4	6	12	26	52
Duration of signs										
1	0.1%	0.1%	0.3%	0.5%	0.8%	1.1%	1.6%	3.3%	7.1%	14.2%
3	0.3%	0.4%	0.8%	1.6%	2.5%	3.3%	4.9%	9.9%	21.4%	42.7%
7	0.8%	1.0%	1.9%	3.8%	5.8%	7.7%	11.5%	23.0%	49.9%	99.7%
14	1.5%	1.9%	3.8%	7.7%	11.5%	15.3%	23.0%	46.0%	99.7%	100.0%
28	3.1%	3.8%	7.7%	15.3%	23.0%	30.7%	46.0%	92.1%	100.0%	100.0%
30	3.3%	4.1%	8.2%	16.4%	24.7%	32.9%	49.3%	98.6%	100.0%	100.0%
92	10.1%	12.6%	25.2%	50.4%	75.6%	100.0%	100.0%	100.0%	100.0%	100.0%
183	20.1%	25.1%	50.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
365	40.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Stochastic modelling of scanning active surveillance

Proportion of farms infected	3%
Days during which signs are detectable	30
Visits per year	6
Days between visits	61

	Farms infected	Infected farms found	Sensitivity	Day of first outbreak	Day of detection
Mean	3.1	1.5	48.9%	79	111.9
Median	3	1	50.0%	50.5	90
Min	0	0	0.0%	1	0
Max	10	6	100%	302	359
n	100	100	94	100	100

Proportion of farms infected	20%
Days during which signs are detectable	30
Visits per year	12
Days between visits	30

	Farms infected	Infected farms found	Sensitivity	Day of first outbreak	Day of detection
Mean	22.3	20.3	91.0%	2.4	15.3
Median	22.5	20	90.9%	1	10
Min	12	10	71.4%	1	1
Max	31	29	100%	26	96
n	100	100	100	100	100

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7	0.8%	1.0%	1.9%	3.8%	5.8%	7.7%	11.5%	23.0%	49.9%	99.7%
14	1.5%	1.9%	3.8%	7.7%	11.5%	15.3%	23.0%	46.0%	99.7%	100.0%
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92	10.1%	12.6%	25.2%	50.4%	75.6%	100.0%	100.0%	100.0%	100.0%	100.0%
183	20.1%	25.1%	50.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
365	40.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

- Gap between visits must be no greater than the duration of detectable signs
- Even so, detection will occur on average half way through duration of signs

Participatory surveillance

- Participatory epidemiology
- Participatory disease search (PDS)
- Participatory disease search and response (PDSR)

- Participation?
- Talk to producers and ask them for information about disease occurrence
- Extractive rather than participatory?

PDSR in Indonesia

- PDSR in Indonesia
- Covers around 50,000 villages
- Current visit rate is around 40% visited each year
- Goal is to detect highly pathogenic avian influenza
- Largest participatory active surveillance system to date
- Costly in manpower and resources

- Of over 1,000 confirmed outbreaks, only 3.5% were detected during active surveillance visits

The problem for PDSR in Indonesia

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183	20.1%	25.1%	50.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
365	40.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

- How long are clinical signs detectable in a village?
- How often can a village be visited?
- How quickly is an outbreak detected?

Active surveillance: conclusions

- Inadequate sensitivity unless the visits are spaced to be less than or equal to the duration of the detectable signs
- For acute infectious diseases, the minimum would be monthly visits
- Even with high frequency of visits, delay to detection is likely to be a serious issue and have little impact on initial spread
- Even around outbreaks, most cases are reported by keepers and active surveillance does not find them more quickly (McLaws, FMD) (but still important to do this)

Active surveillance: conclusions

- Active surveillance works well for diseases with
  - long duration of detection
  - inapparent or intermittent clinical signs
  - e.g. bovine TB, brucellosis
- Active surveillance can be used to estimate how much disease is present
- Use likely sensitivity of active surveillance to estimate how much disease is present
- Periodic check of the sensitivity of passive surveillance by finding unreported disease and comparing rates

PDSR in Indonesia as a check on passive surveillance

- PDSR in Indonesia has found around 30 cases, passive surveillance has found around 1,000 over a 9 month period
- Probable sensitivity of PDSR is 3-4%
- Expected cases would be (30 * 100/3) = approx 1,000
- Passive surveillance seems to be working well?
- But other problems with PDSR

FMD participatory epidemiology

- Compared farmer report of FMD like symptoms to NS protein test (detects infection)
- Quotes the positive predictive value of herder report as 93%

Why did PDS work for Rinderpest?

- Rinderpest was eradicated in North east Africa
- PDS was developed in the final stages of the campaign
- Identified pockets of infection using owner reports of disease
- Positive reports followed by ring vaccination around the report
- PDS credited as important tool in achieving eradication

Why did PDS work for Rinderpest?

- The infection was present for long periods
- The response to infection was non-damaging to the owners. No disincentive to reporting
- The response has a positive protective effect so owners had an incentive to report any suspicions
- The impact of the intervention was long lasting so might be effective in the future even if the diagnosis was incorrect
- Overall, any vaccination increased herd immunity
- Low visit rates not so critical

Targeted active surveillance

- Target according to perceived risk
- Target the high risk locations
- Why does it so often seem to fail?

- Risk estimation has to be accurate
- What does “high” mean?
- Risk targeting must lead to good coverage of overall population risk

Modelling surveillance targeted according to geographical risk

Matrix of 500 farms , 25x20

A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
H	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
J	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Evenly spread risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	1	5%		5%
B	1	5%		10%
C	1	5%		15%
D	1	5%	20%	20%
E	1	5%		25%
F	1	5%		30%
G	1	5%		35%
H	1	5%	40%	40%
I	1	5%		45%
J	1	5%		50%
K	1	5%		55%
L	1	5%	60%	60%
M	1	5%		65%
N	1	5%		70%
O	1	5%		75%
P	1	5%	80%	80%
Q	1	5%		85%
R	1	5%		90%
S	1	5%		95%
T	1	5%	100%	100%

Modelling surveillance targeted according to risk

Those on upper edge may have risk levels higher than the remainder. In this case 50% of farms have double the risk

A	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
B	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
C	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
D	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
E	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
F	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
G	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
H	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
I	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
J	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
K	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

50% of farms have double (2x) risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	2	7%		7%
B	2	7%		13%
C	2	7%		20%
D	2	7%	20%	27%
E	2	7%		33%
F	2	7%		40%
G	2	7%		47%
H	2	7%	40%	53%
I	2	7%		60%
J	2	7%		67%
K	1	3%		70%
L	1	3%	60%	73%
M	1	3%		77%
N	1	3%		80%
O	1	3%		83%
P	1	3%	80%	87%
Q	1	3%		90%
R	1	3%		93%
S	1	3%		97%
T	1	3%	100%	100%

High risk
67%

Low risk
33%

20% of farms have 5x risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk	
A	5	14%		14%	High risk 56%
B	5	14%		28%	
C	5	14%		42%	
D	5	14%	20%	56%	
E	1	3%		58%	
F	1	3%		61%	
G	1	3%		64%	
H	1	3%	40%	67%	
I	1	3%		69%	
J	1	3%		72%	
K	1	3%		75%	
L	1	3%	60%	78%	
M	1	3%		81%	
N	1	3%		83%	Low risk 44%
O	1	3%		86%	
P	1	3%	80%	89%	
Q	1	3%		92%	
R	1	3%		94%	
S	1	3%		97%	
T	1	3%	100%	100%	

10% of farms have 10x risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	10	26%		26%
B	10	26%		53%
C	1	3%		55%
D	1	3%	20%	58%
E	1	3%		61%
F	1	3%		63%
G	1	3%		66%
H	1	3%	40%	68%
I	1	3%		71%
J	1	3%		74%
K	1	3%		76%
L	1	3%	60%	79%
M	1	3%		82%
N	1	3%		84%
O	1	3%		87%
P	1	3%	80%	89%
Q	1	3%		92%
R	1	3%		95%
S	1	3%		97%
T	1	3%	100%	100%

High risk
53%

Low risk
47%

20% of farms have 10x risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	10	18%		18%
B	10	18%		36%
C	10	18%		54%
D	10	18%	20%	71%
E	1	2%		73%
F	1	2%		75%
G	1	2%		77%
H	1	2%	40%	79%
I	1	2%		80%
J	1	2%		82%
K	1	2%		84%
L	1	2%	60%	86%
M	1	2%		88%
N	1	2%		89%
O	1	2%		91%
P	1	2%	80%	93%
Q	1	2%		95%
R	1	2%		96%
S	1	2%		98%
T	1	2%	100%	100%

High risk
71%

Low risk
29%

10% of farms have 20x risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	20	34%		34%
B	20	34%		69%
C	1	2%		71%
D	1	2%	20%	72%
E	1	2%		74%
F	1	2%		76%
G	1	2%		78%
H	1	2%	40%	79%
I	1	2%		81%
J	1	2%		83%
K	1	2%		84%
L	1	2%	60%	86%
M	1	2%		88%
N	1	2%		90%
O	1	2%		91%
P	1	2%	80%	93%
Q	1	2%		95%
R	1	2%		97%
S	1	2%		98%
T	1	2%	100%	100%

High risk
69%

Low risk
31%

20% of farms have 20x risk

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk	
A	20	21%		21%	High risk 83%
B	20	21%		42%	
C	20	21%		63%	
D	20	21%	20%	83%	
E	1	1%		84%	
F	1	1%		85%	
G	1	1%		86%	
H	1	1%	40%	88%	
I	1	1%		89%	
J	1	1%		90%	
K	1	1%		91%	
L	1	1%	60%	92%	
M	1	1%		93%	
N	1	1%		94%	Low risk 17%
O	1	1%		95%	
P	1	1%	80%	96%	
Q	1	1%		97%	
R	1	1%		98%	
S	1	1%		99%	
T	1	1%	100%	100%	

Graded risk: 20% at 20x, 10% at 10x, 5% at 5x and 5% at 2x

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	20	17%		17%
B	20	17%		34%
C	20	17%		50%
D	20	17%	20%	67%
E	10	8%		76%
F	10	8%		84%
G	5	4%		88%
H	2	2%	40%	90%
I	1	1%		91%
J	1	1%		92%
K	1	1%		92%
L	1	1%	60%	93%
M	1	1%		94%
N	1	1%		95%
O	1	1%		96%
P	1	1%	80%	97%
Q	1	1%		97%
R	1	1%		98%
S	1	1%		99%
T	1	1%	100%	100%

Highest risk 67%

90% of risk in 40% of farms

Lower risk 33%

Graded risk: 5% each 20x, 10x, 5x and 2x

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	20	38%		38%
B	10	19%		57%
C	5	9%		66%
D	2	4%	20%	70%
E	1	2%		72%
F	1	2%		74%
G	1	2%		75%
H	1	2%	40%	77%
I	1	2%		79%
J	1	2%		81%
K	1	2%		83%
L	1	2%	60%	85%
M	1	2%		87%
N	1	2%		89%
O	1	2%		91%
P	1	2%	80%	92%
Q	1	2%		94%
R	1	2%		96%
S	1	2%		98%
T	1	2%	100%	100%

High risk
38% - 70%

Lower risk
62% - 30%

Graded risk: 5% each 10x, 5x and 2x

	Relative risk per row	% of total risk per row	Cumulative % farms	Cumulative % of total risk
A	10	29%		29%
B	5	15%		44%
C	2	6%		50%
D	1	3%	20%	53%
E	1	3%		56%
F	1	3%		59%
G	1	3%		62%
H	1	3%	40%	65%
I	1	3%		68%
J	1	3%		71%
K	1	3%		74%
L	1	3%	60%	76%
M	1	3%		79%
N	1	3%		82%
O	1	3%		85%
P	1	3%	80%	88%
Q	1	3%		91%
R	1	3%		94%
S	1	3%		97%
T	1	3%	100%	100%

High risk

29% - 50%

Lower risk

71% - 50%

Risk based targeted surveillance in reality

- Have to identify the real risk factors
- Covering more than two thirds of the risk is difficult unless there is a very large difference in risk levels and a sharp cut off between ‘high” and “low”
- The savings in man power in peace time may well be offset by the increased size and duration of an outbreak if the initial case(s) are missed

Temporal risk based surveillance

- Same issues apply
- Must be significant difference in risk and with a clear boundary

- If temporal and geographical risks are combined, problem becomes more severe
- 67% of 67% is 44%

Active surveillance at concentration points

- Slaughterhouses, markets
- Animals to be sampled are brought to the point frequently and from a wide area
- Can be useful for diseases with unclear clinical signs
  - CSF / tonsils
- Can be useful for detecting new introductions
- Identifying source can be difficult
- Delays in detection because relies on animals being moved

The take home messages 1

- Active surveillance, scanning or targeted, cannot replace passive surveillance for the detection of acute infectious diseases unless substantial resources are sustainably available
- Participatory epidemiology suffers from the same problems of low sensitivity and delays in detection as any other active surveillance system
- Risk based targeted active surveillance will only be safe to use where there are very large risk differentials with clear cut offs

There is no substitute for passive surveillance

The take home messages 2

- Passive surveillance systems need to be at least 60-70% sensitive
- This is possible but requires effort
- Stakeholder engagement
  - what to report
  - how to report
  - consequences of reporting
- Public awareness
  - markets
- Removal of disincentives to reporting
- Resources better used to achieve this than for targeted surveillance
- Check sensitivity using periodic random active surveys

The take home messages 3

- We need a better term than “passive” to adequately describe a surveillance system that has to be actively maintained and that involves many people taking actions that currently are not recorded or acknowledged
- Community (based/led) surveillance?
  - It is undertaken by the community
  - but vet services still involved
- Primary surveillance?
  - surveillance occurs at the primary producer level
  - it is the primary level of surveillance
  - it is the most important form of surveillance

Questions / Discussion