Patterns of Resistance in the US

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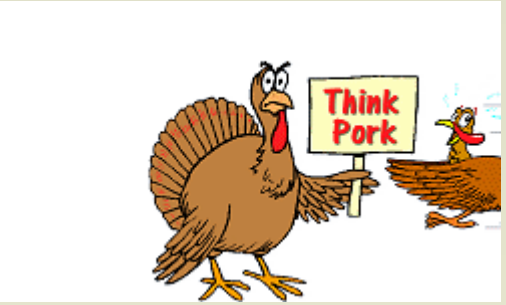
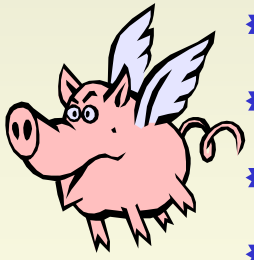
4/27/2006

Acknowledgements





- Dr. Mark Englen
- Dr. Charlene Hudson
- Dr. Jonathan Frye
- Dr. Stan Bailey
- Dr. Mark Berrang
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- Takiyah Ball
- Carolina Hall
- Scott Ladely
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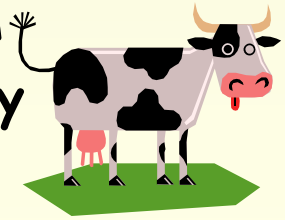
- Doug Cosby



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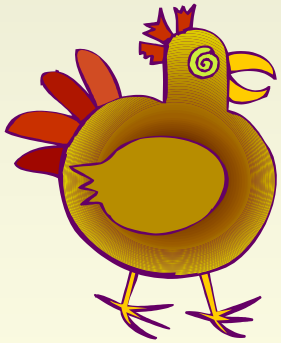


Preliminary data; subject to change; not for public distribution

Acknowledgements

FDA-CVM

- Dave White
- Pat McDermott

USDA-APHIS

- Dr. Dave Dargatz
- Dr. Nora Wineland

CDC – Human NARMS

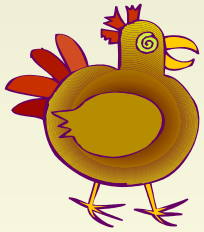
- Dr. Tom Chiller
- Dr. Fred Angulo

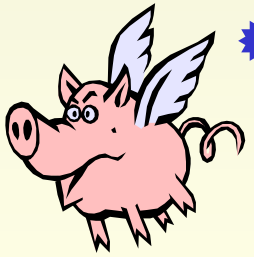
USDA-FSIS

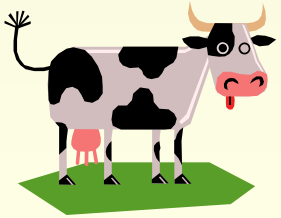
- Dr. Ben Salamone
- Dr. Neena Anandaraman
- Bonnie Rose

Non-federal partners

- Vet diagnostic labs

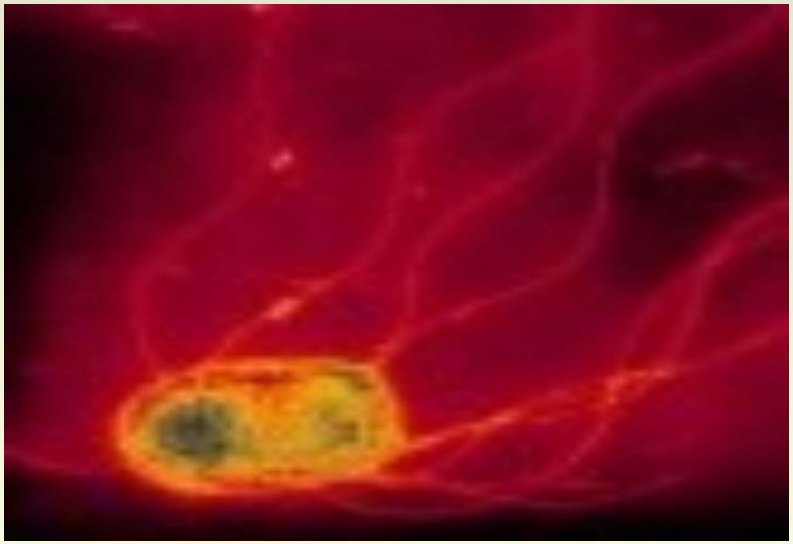


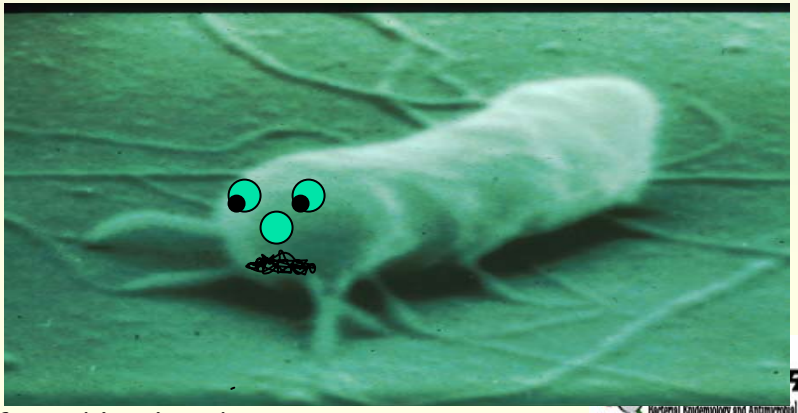




Salmonella

- Over 50,000 isolates tested since 1997
- Serotypes
  - Vary over time
  - Vary by source





Important Report Differences

- Retail/Human NARMS do not differentiate between Typhimurium and Typhimurium 5-
  - Differences in resistance profiles
  - Differences in pathogenicity
- Their reports do not confirm ACSSuT as DT104

"I'm so full of antibiotics, every time I sneeze, I cure somebody."

http://www.molbio.princeton.edu/courses/mb427/1999/projects/9912/cartoon.gif

Serotypes in humans

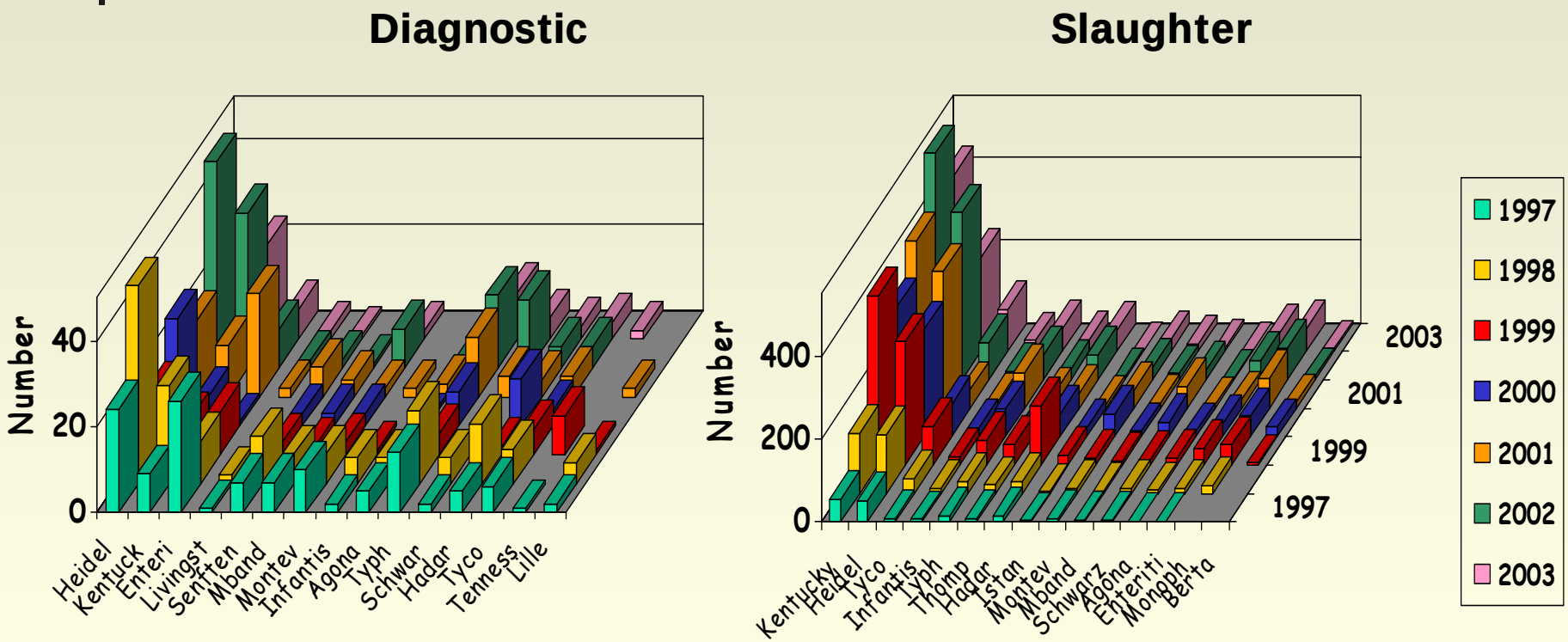
2000	2001	2002	2003
Enteritidis	Typhimurium	Typhimurium	Typhimurium
Typhimurium	Enteritidis	Enteritidis	Enteritidis
Newport	Newport	Newport	Newport
Heidelberg	Heidelberg	Javiana	Heidelberg
Javiana	Javiana	Heidelberg	Javiana
Thompson	Oranienberg	Montevideo	St. Paul
Montevideo	Montevideo	St. Paul	Muenchen
Muenchen	Muenchen	Oranienberg	Oranienberg
St. Paul	Thompson	I 4,[5],12:i:-	Montevideo
Hadar	St. Paul	Infantis	Monophasic Typhimurium

Serotype – animals all sources aggregated

1997-2002	2003	2004	2005
Heidelberg	Kentucky	Kentucky	Kentucky
Kentucky	Typhimurium 5-	Typhimurium 5-	Heidelberg
Typhimurium 5-	Newport	Typhimurium	Typhimurium var 5-
Typhimurium	Heidelberg	Heidelberg	Typhimurium
Montevideo	Typhimurium	Newport	Enteritidis
Derby	Hadar	Derby	Derby
Newport	Agona	Montevideo	Newport
Anatum	Montevideo	Anatum	Montevideo
Agona	Choleraesuis	Choleraesuis	Hadar
Hadar	Enteriditis	Agona	Infantis

	Top serotypes by Source for Salmonella slaughter isolates (1997-2005)							
	SOURCE							
Rank	Cattle n=6815		Chicken n=10,605		Swine n=3,839		Turkey n=3,147	
	Serotype	Pct	Serotype	Pct	Serotype	Pct	Serotype	Pct
1	Montevideo	13.4%	Kentucky	35.5%	Derby	25.8%	Heidelberg	20.7%
2	Anatum	8.9%	Heidelberg	20.3%	Typhimurium var 5-[a]	11.2%	Hadar	16.6%
3	Newport	7.6%	Typhimurium var 5-[a]	6.1%	Infantis	6.5%	Senftenberg	8.2%
4	Muenster	7.1%	Typhimurium	4.9%	Johannesburg	6.3%	Reading	7.3%
5	Typhimurium	5.6%	Enteritidis	4.3%	Anatum	6.1%	Saint Paul	6.5%
6	Typhimurium var 5-[a]	5.5%	Hadar	4.0%	Heidelberg	3.9%	Agona	5.0%
7	Kentucky	5.1%	Monophasic	3.1%	Reading	3.9%	Schwarzengrund	4.4%
8	Cerro	4.0%	Thompson	2.3%	Saint Paul	3.0%	Muenster	3.8%
9	Mbandaka	3.9%	Schwarzengrund	2.2%	Typhimurium	2.8%	Arizona	2.7%
10	Agona	3.8%	Montevideo	2.2%	Agona	2.7%	Typhimurium	2.6%

Source (Chicken) by clinical status by year



Preliminary data; subject to change; not for public distribution

What about resistance between serotypes?

2004	SEROTYPE (%R) [all animals]						
ANTIMICROBIAL	Kentucky N=635	Typh 5- N=441	Typh N=387	Heidelberg N=306	Newport N=305	Derby N=229	Enteritidis N=113
Amox/Clav	8.7	20.2	16.3	15.0	73.4	8.3	1.8
Ampicillin	10.1	74.4	53.0	22.2	76.4	10.9	4.4
Cefoxitin	8.7	19.5	15.8	15.0	72.1	8.3	1.8
Ceftiofur	8.7	19.5	17.8	15.0	73.4	8.3	1.8
Ceftriaxone	0	0.9	0.5	0.7	4.9	0	0
Chloramphenicol	0.8	47.8	43.2	9.8	72.1	5.2	0.9
Gentamicin	1.9	6.6	8.8	13.4	16.4	7.0	1.8
Kanamycin	0.5	19.0	15.2	25.8	28.5	7.0	0.9
Nalidixic Acid	0.2	1.1	2.8	0	1.3	0	0
Streptomycin	31.2	61.5	53.2	32.7	78.7	60.7	4.4
Sulfamethoxazole	3.9	78.2	58.4	21.6	77.7	59.8	2.7
Tetracycline	37.8	75.7	56.8	39.5	79.0	70.7	4.4
Trimethoprim/Sulfa	0.2	5.0	9.3	3.6	4.3	1.7	0

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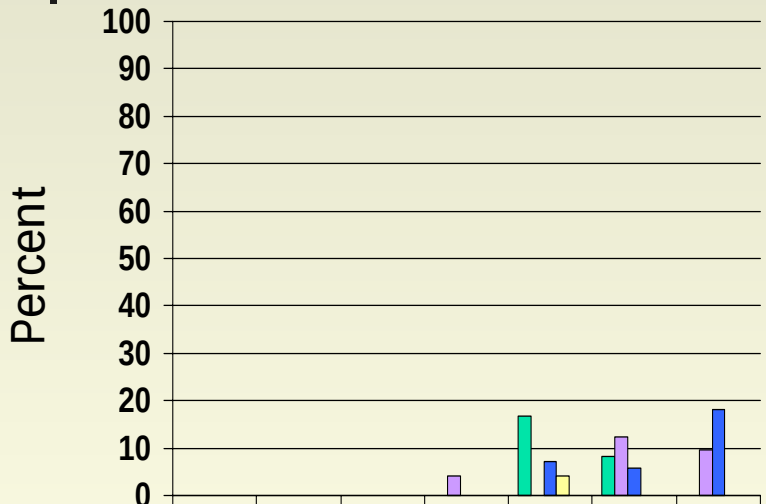
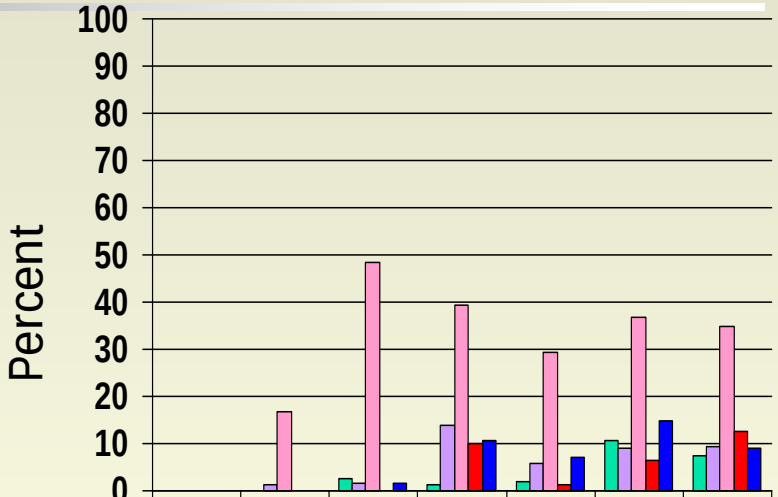
Ceftiofur Resistance - Top Serotypes for *Salmonella* Isolates from Chicken

Diagnostic



	'97	'98	'99	'00	'01	'02	'03
Kentucky	0	0	0	0	16.7	8.3	0
Heidelberg	0	0	0	4	0	12.5	9.5
Typhimurium	0	0	0	0	7.1	5.9	18.2
Enteriditis	0	0	0	0	4.2	0	0
Pullorum	0	0	0	0	0	0	0

Slaughter

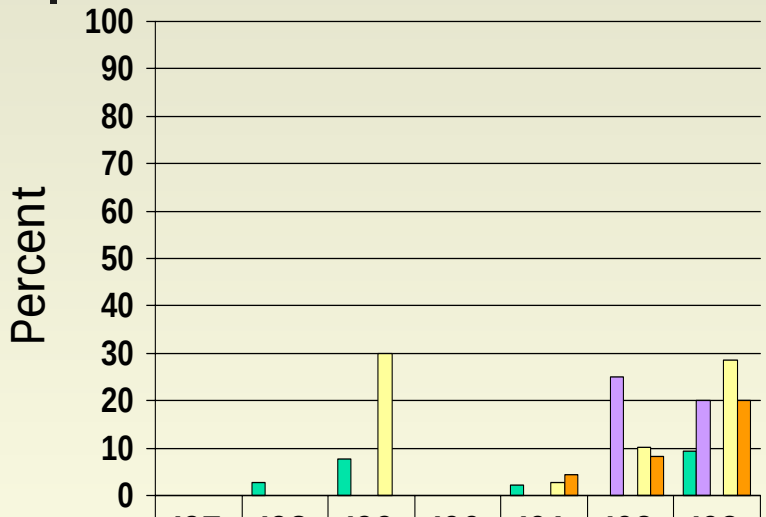


	'97	'98	'99	'00	'01	'02	'03
Kentucky	0	0	2.5	1.3	2	10.8	7.3
Heidelberg	0	1.4	1.7	13.9	5.8	8.9	9.3
Typh 5-	0	16.7	48.4	39.2	29.5	36.7	34.7
Monophasic	0	0	0	10	1.4	6.5	12.5
Typhimurium	0	0	1.6	10.6	7	15	9.1

Preliminary data; subject to change; not for public distribution

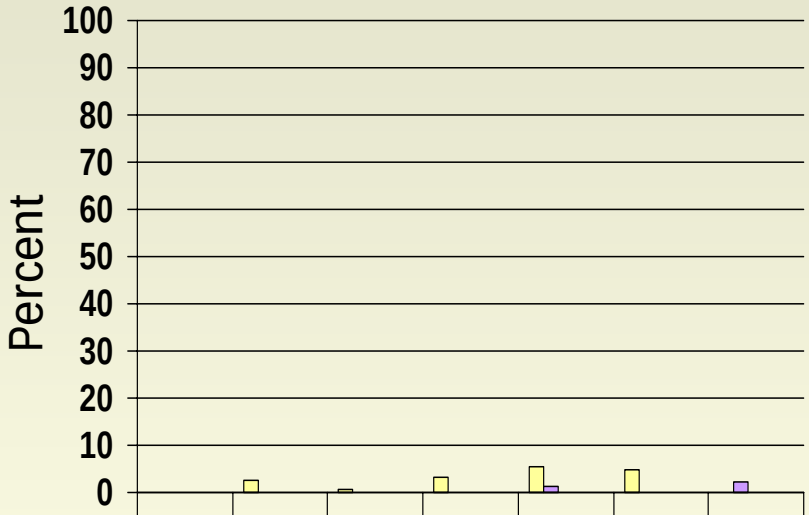
Ceftiofur Resistance - Top Serotypes for *Salmonella* Isolates from Turkey

Diagnostic



	'97	'98	'99	'00	'01	'02	'03
Senftenberg	0	2.8	7.7	0	2.2	0	9.4
Hadar	0	0	0	0	0	25	20
Muenster	0	0	0	0	0	0	0
Heidelberg	0	0	30	0	2.8	10.3	28.6
Montevideo	0	0	0	0	4.5	8.3	20

Slaughter



	'97	'98	'99	'00	'01	'02	'03
Heidelberg	0	2.6	0.7	3.2	5.6	5	0
Hadar	0	0	0	0	1.2	0	2.3
Arizona	0	0	0	0	0	0	0
Reading	0	0	0	0	0	0	0
Saint Paul	0	0	0	0	0	0	0

Preliminary data; subject to change; not for public distribution

Salmonella - MDR

	1997	1998	1999	2000	2001	2002	2003	2004	2005*
Animal Tot. # Tested	2391	3318	8508	7834	5739	6977	5353	4873	3728
Total # Pan Susc. (%)	65.8	51.9	55.7	52.9	48.4	52.3	48.7	48.1	52.8
Total # R = 1 (%)	9.4	8.1	8.8	9.8	7.5	8.0	8.2	7.7	7.6
Total # R ≥ 5 (%)	11.1	17.9	14.7	19.4	22.3	22.3	25.2	24.2	18.2
Total # R ≥ 10 (%)	0.8	2.0	1.3	5.5	5.4	7.4	7.0	3.2	2.8

*2005 Preliminary Data

Salmonella – % Pan Susc

	1997	1998	1999	2000	2001	2002	2003	2004	2005*
All	65.8	51.9	55.7	52.9	48.4	52.3	48.7	48.2	52.8
Human	66.2	68.3	74.0	74.4	72.2	78.9	77.5	ND	ND
Cattle	67.5	64.7	69.0	64.2	62.8	58.8	56.8	53.0	57.5
Swine	45.4	42.5	53.9	34.3	28.0	24.0	26.5	22.3	29.6
Chicken	61.6	58.6	58.6	57.9	65.5	60.7	60.2	62.8	61.4
Turkey	31.3	30.7	31.5	28.9	28.2	27.3	21.8	28.7	27.5

*2005 Preliminary Data

Percent Multiple Resistance - Top Serotypes from Slaughter Chicken Isolates 1999-2004

Rank	Serotype	Pan-Susceptible	>2 ABX	>5 ABX	>10 ABX
1	Kentucky	63.0%	29.8%	5.7%	0.0%
2	Heidelberg	62.0%	27.5%	8.1%	2.8%
3	Typh var 5-	22.3%	74.0%	47.4%	0.2%
4	Typhimurium	65.7%	27.5%	12.4%	1.3%
5	Hadar	8.1%	65.0%	2.5%	0.0%
6	Monophasic	63.5%	27.7%	6.1%	0.0%
7	Enteritidis	94.4%	4.1%	1.5%	0.0%
8	Montevideo	76.5%	20.6%	2.9%	1.5%
9	Thompson	90.8%	7.7%	3.6%	0.0%
10	Schwarzengrund	79.3%	13.0%	3.0%	0.0%

Percent Multiple Resistance - Top Serotypes from Slaughter Turkey Isolates 1999-2004

Rank	Serotype	Pan-Susceptible	>2 ABX	>5 ABX	>10 ABX
1	Heidelberg	28.4%	47.5%	9.6%	0.7%
2	Hadar	4.5%	78.8%	8.7%	0.0%
3	Senftenberg	35.8%	52.1%	31.2%	0.5%
4	Reading	73.6%	17.6%	2.7%	0.0%
5	Saint Paul	7.7%	72.9%	38.1%	0.0%
6	Agona	30.3%	58.0%	11.8%	3.4%
7	Schwarzengrund	64.0%	28.8%	6.3%	0.0%
8	Muenster	32.1%	56.8%	33.3%	0.0%
9	Arizona	67.5%	9.1%	1.3%	0.0%
10	Typhimurium	9.2%	83.1%	58.5%	35.4%

Ciprofloxacin Resistant *Salmonella* Isolates NARMS 1997-2005*

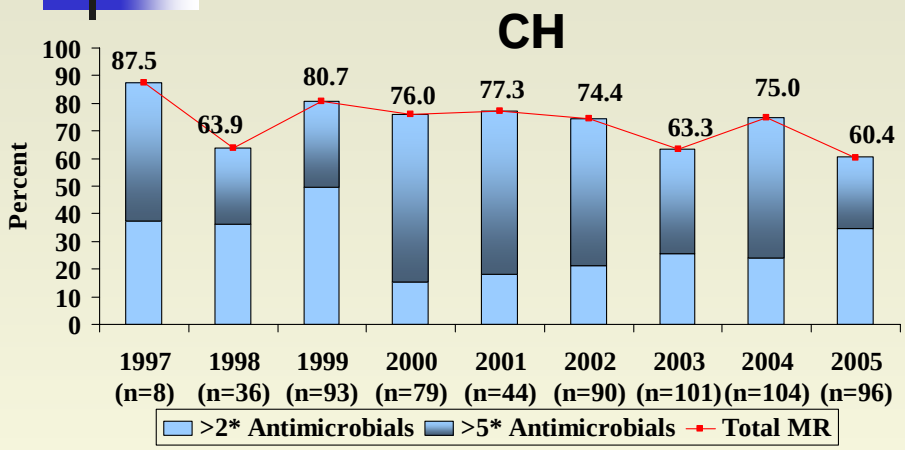
SEROTYPE			
S.NIAK	S.NEWP	S.TYPH	S.KENT
YEAR			
2000	2002	2002	2003
STATUS			
DIAGNOSTIC	DIAGNOSTIC	DIAGNOSTIC	SLAUGHTER
SOURCE			
Cattle	Cattle	Cattle	Chicken
RESISTANCE PROFILE			
AmpChlCipKanNalStrSulTetTri	AmoAmpFoxTioCepChlCipGenKanNalStrSulTetTri	AmoAmpFoxCepChlCipGenKanNalStrSulTetTri	AmoAmpTioAxoCepChlCipGenKanNalStrSulTet

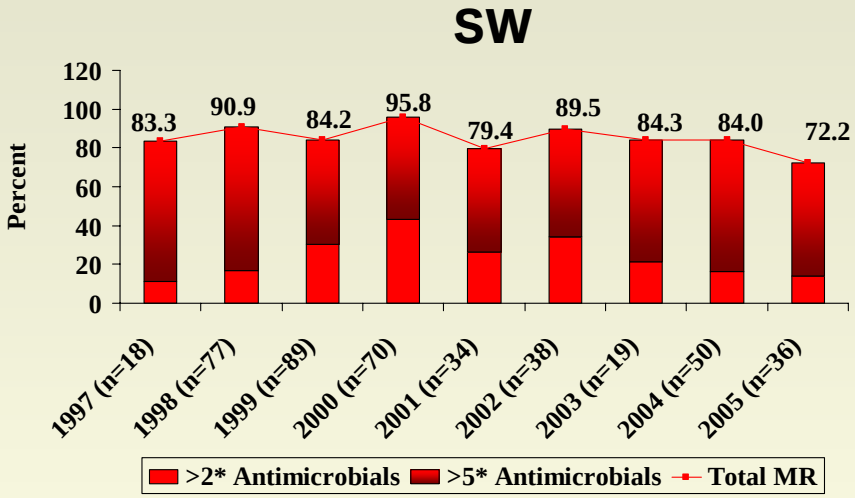
No Ciprofloxacin Resistant isolates found in 2004 or 2005

*Preliminary 2005 Data

Preliminary data; subject to change; not for public distribution

Percent Multiple Resistance
S. Typhimurium 5-; slaughter





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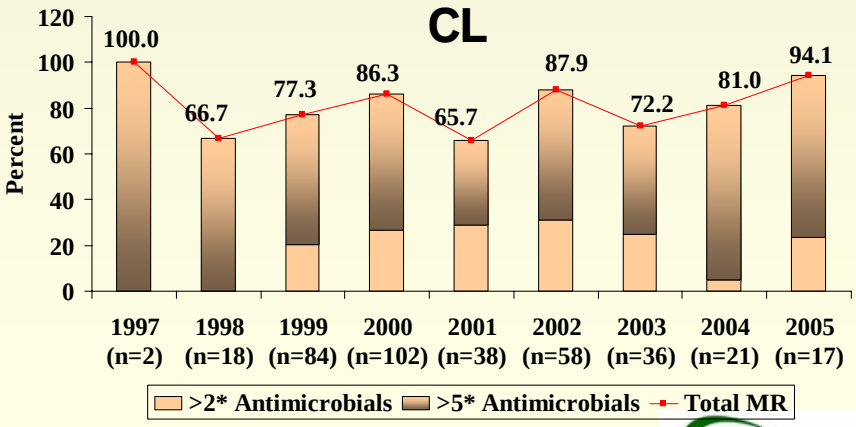

*"> " = greater than or equal to

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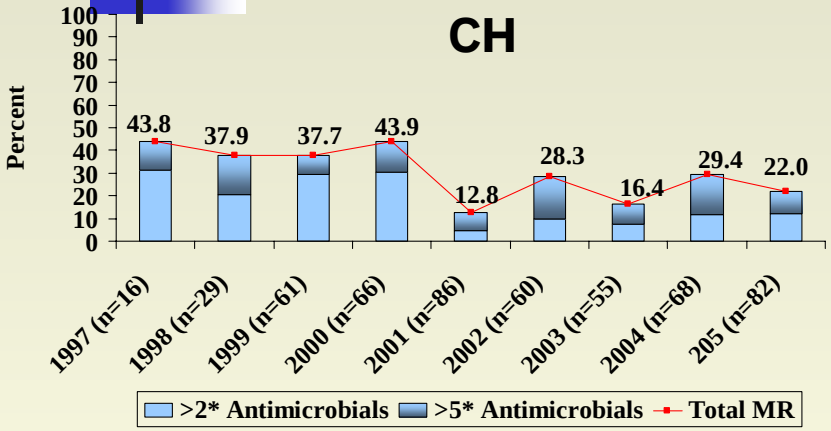
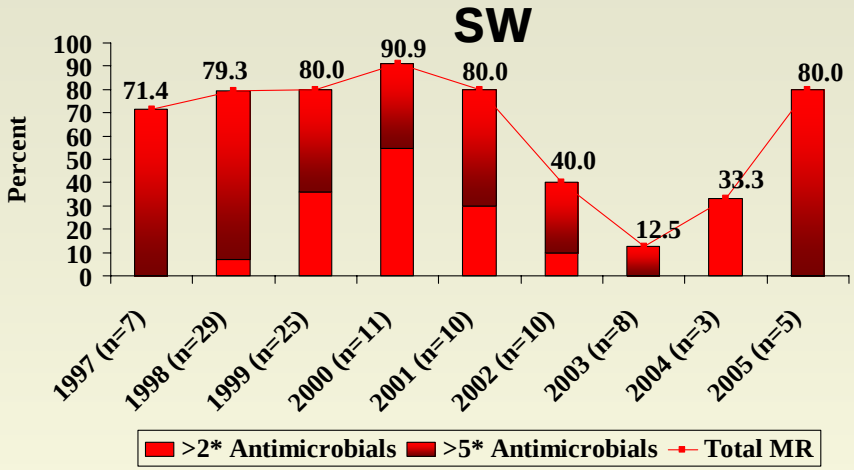
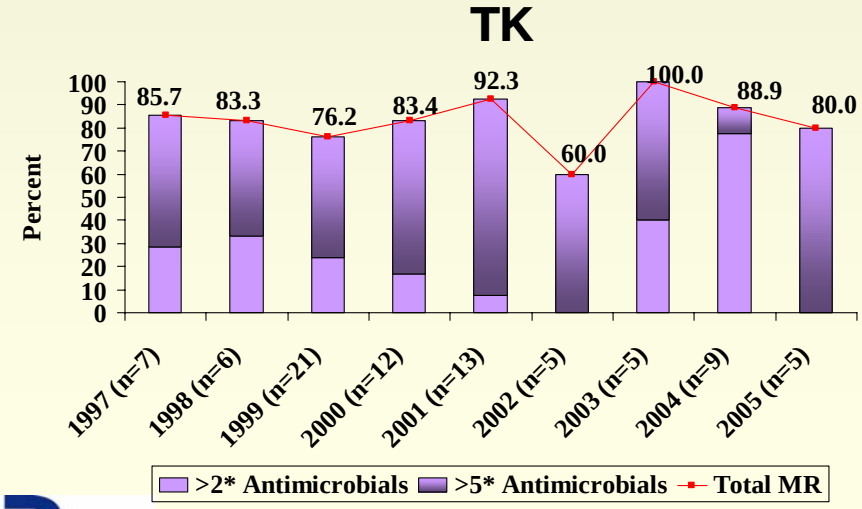
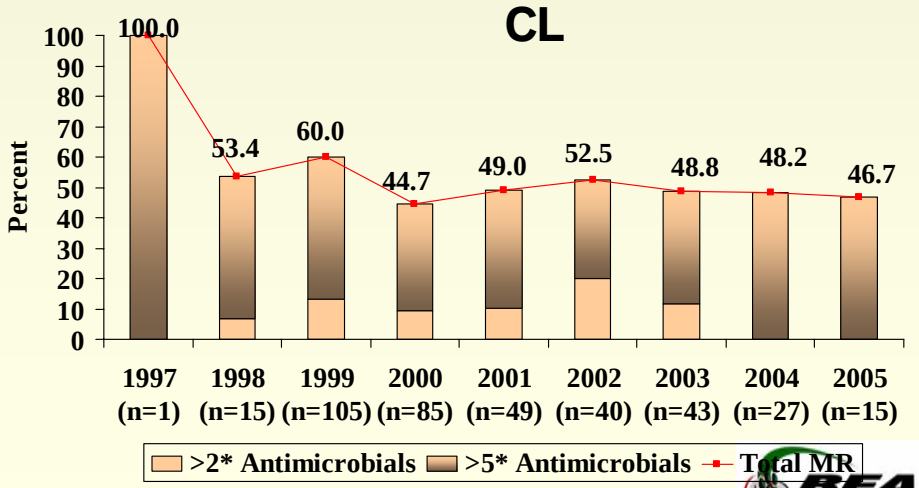
Percent Multiple Resistance *S.* Typhimurium from slaughter









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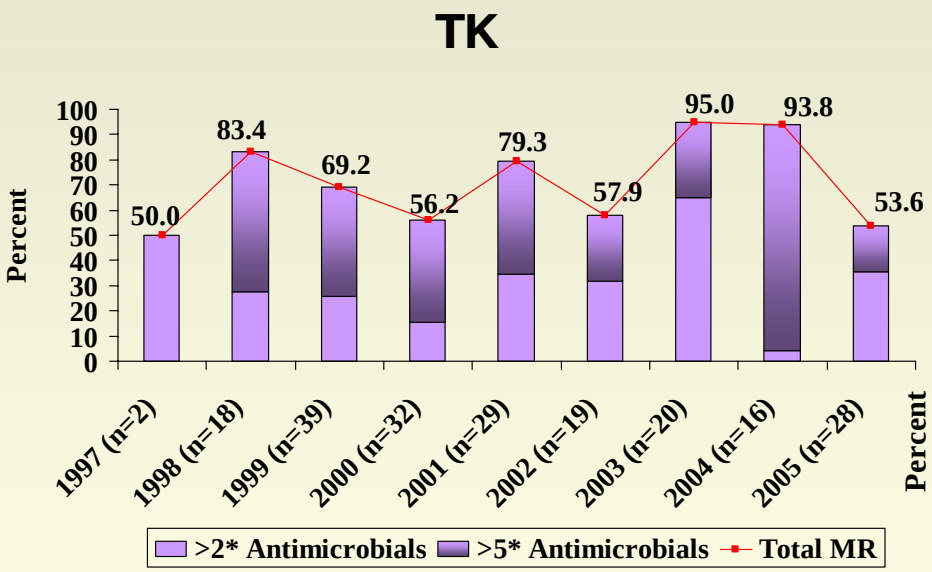
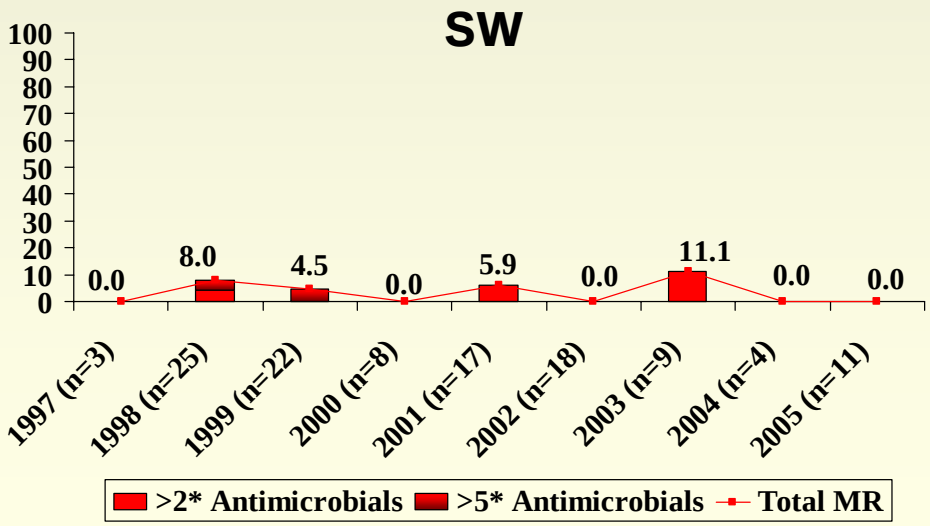
Percent Multiple Resistance *S.* Saint Paul from slaughter





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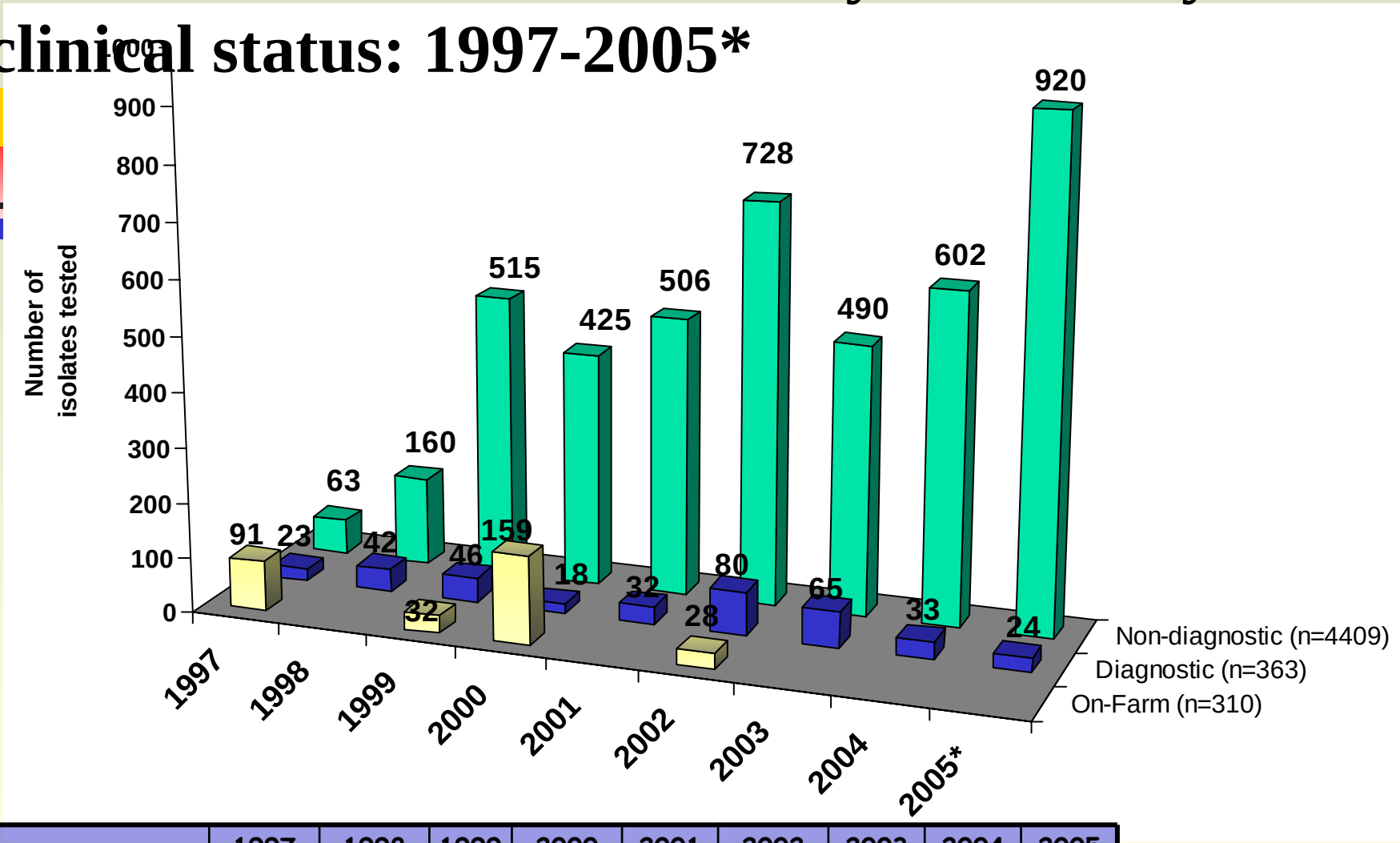
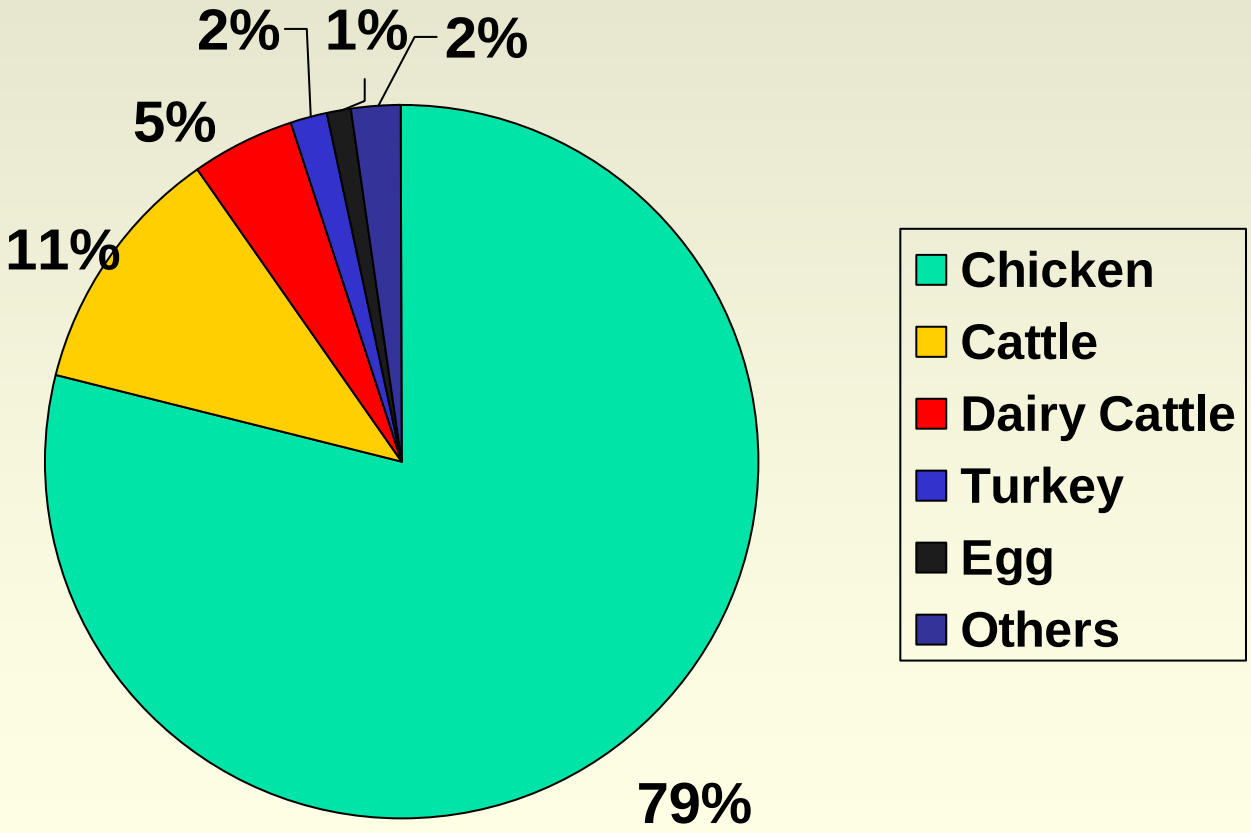
Distribution of all *S.* Kentucky isolates by clinical status: 1997-2005*



	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total No. of Kentucky	177	202	593	602	538	836	555	635	944
Total No. of Salmonella	2391	3318	8508	7834	5739	6977	5353	4873	3728
% Kentucky's for year	7.4%	6.1%	7.0%	7.7%	9.4%	12.0%	10.4%	13.0%	25..3%

* Preliminary 2005 Data

Distribution Kentucky by source regardless of clinical status



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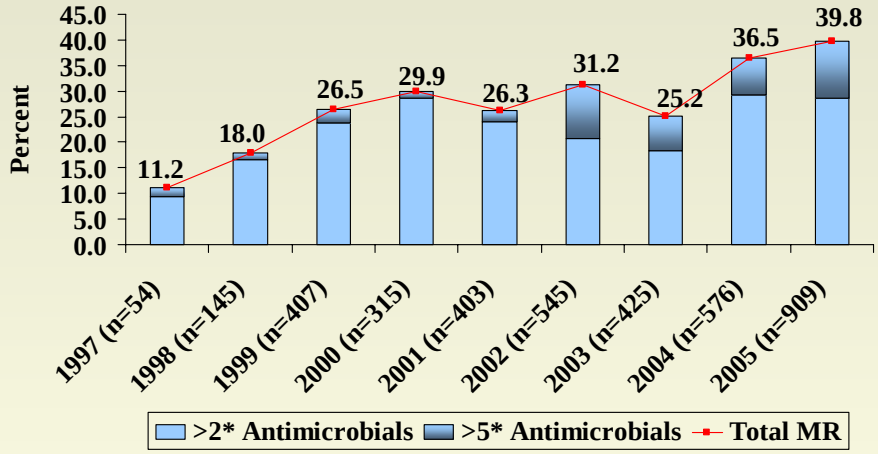
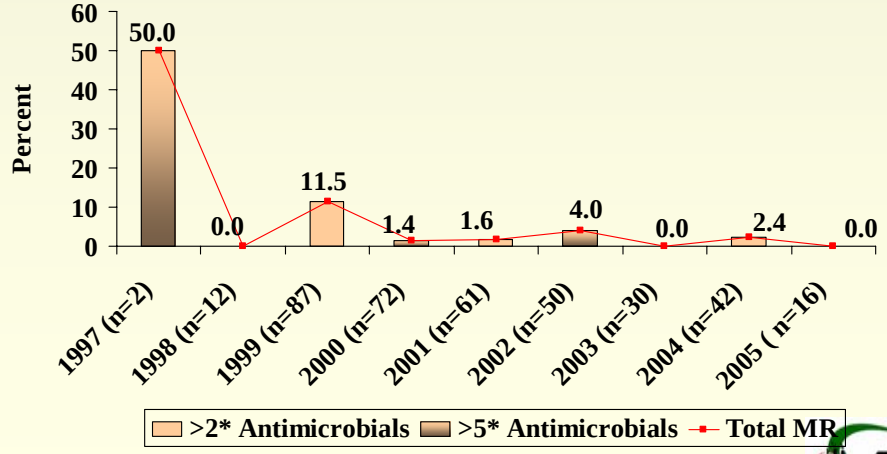
Percent Multiple Resistance
S. Kentucky regardless of clinical status

CHICKEN



CATTLE



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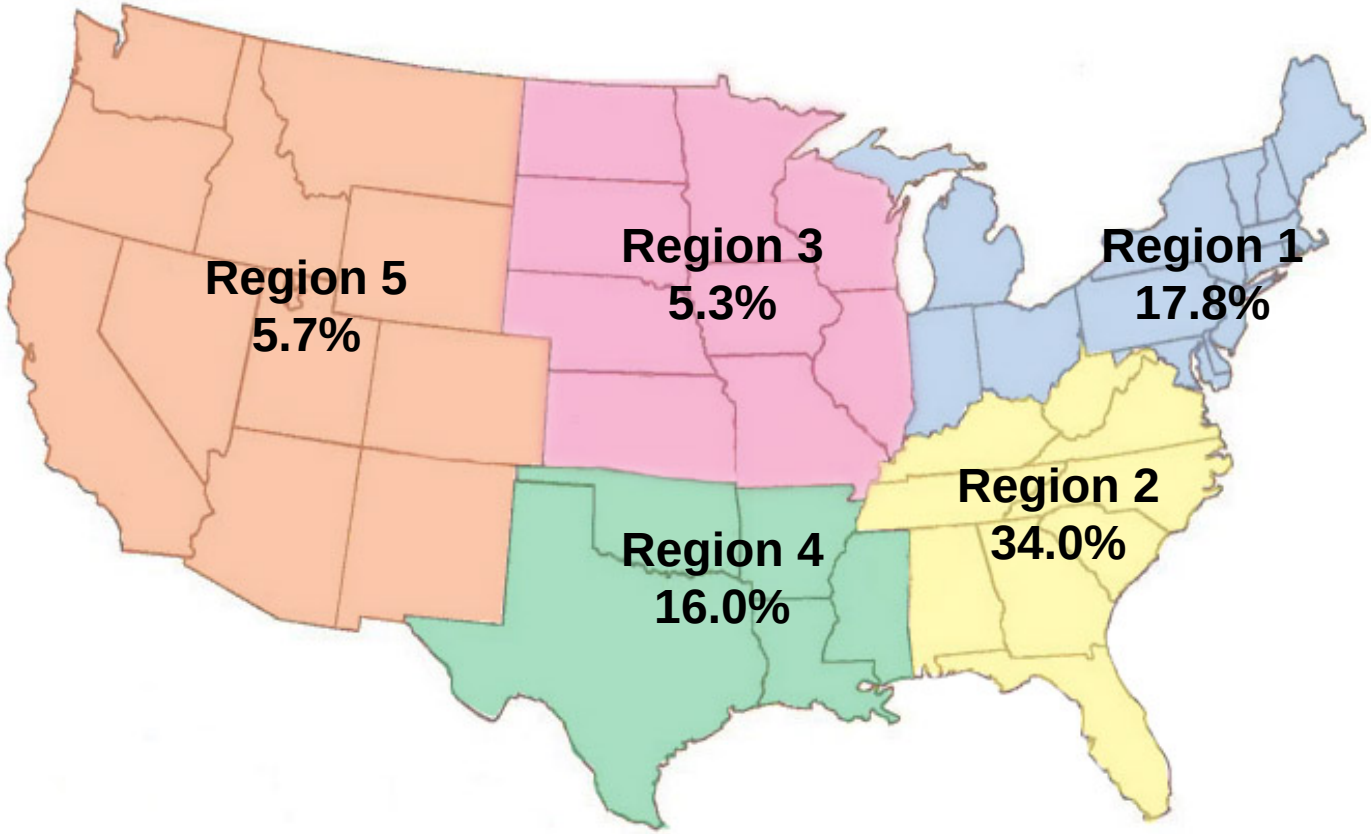
Distribution of *S.* Kentucky by region: 1999-2005*



Region 6: HI, Guam, VI, Mariana 0.5%

*Preliminary 2005 data

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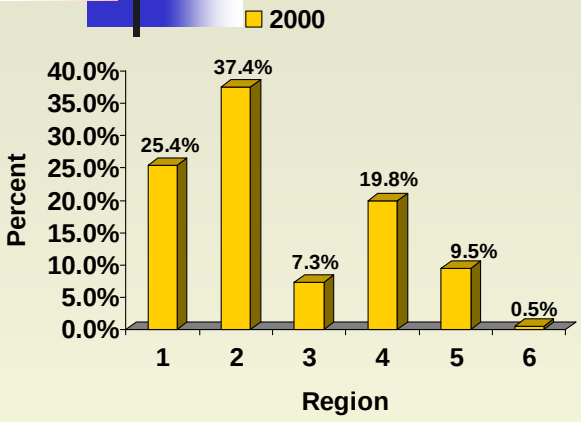
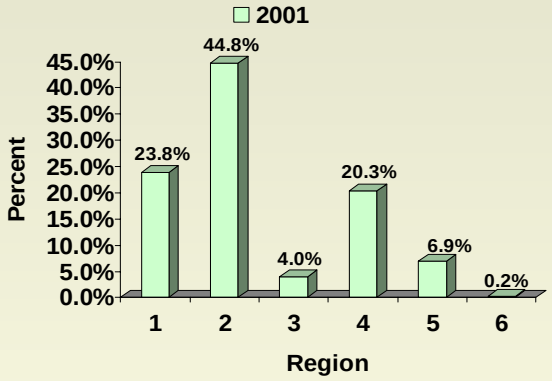
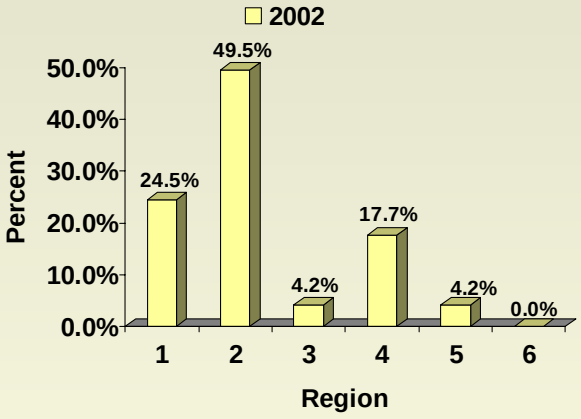
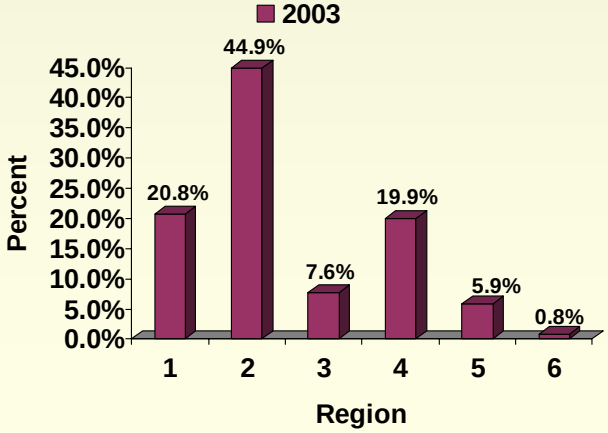
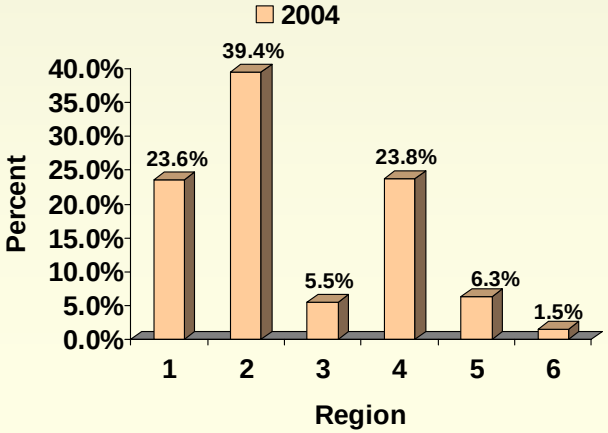
Distribution of *S.* Kentucky by year and region

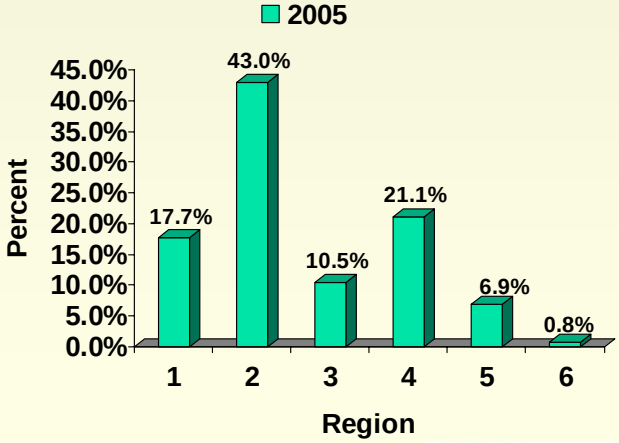






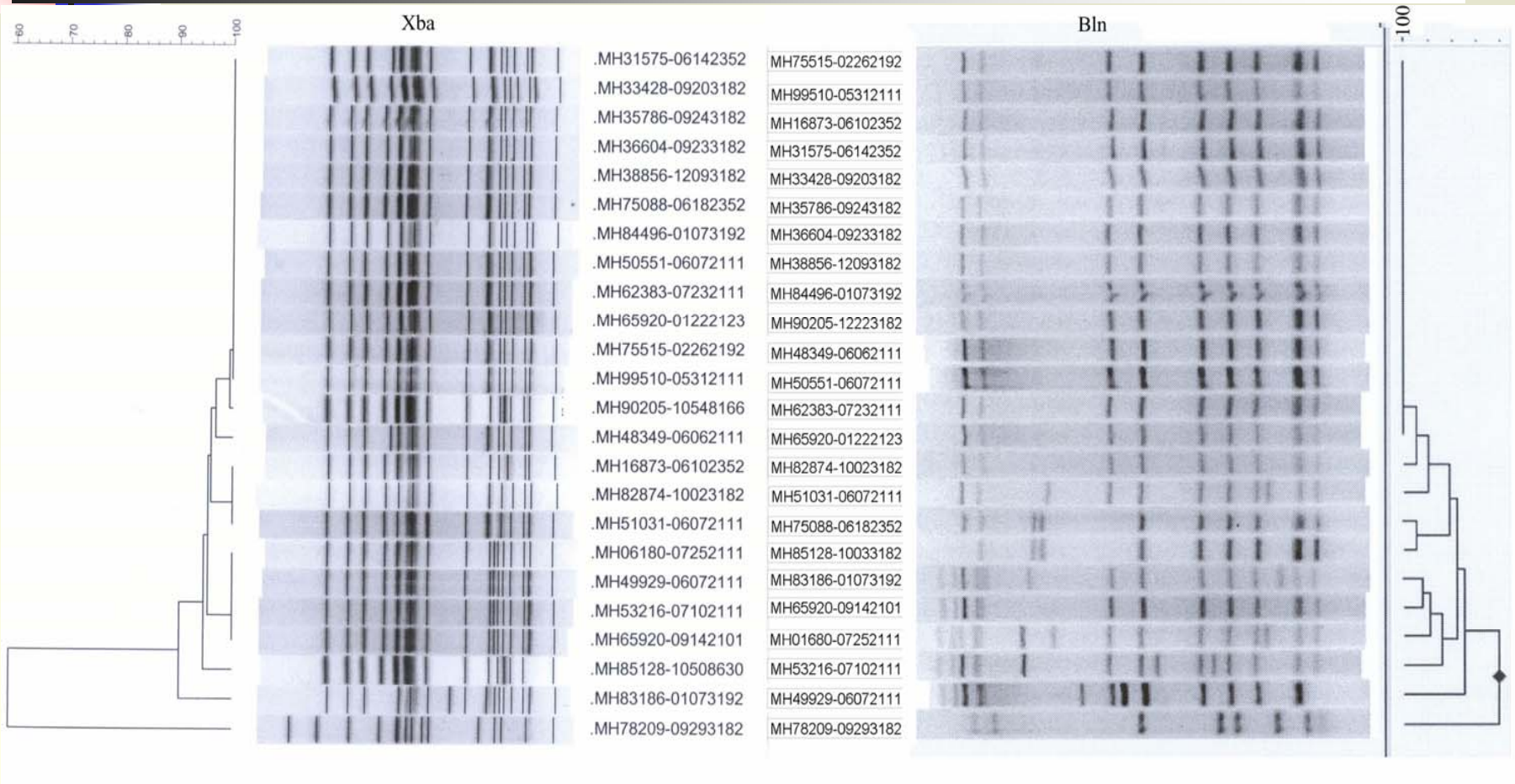






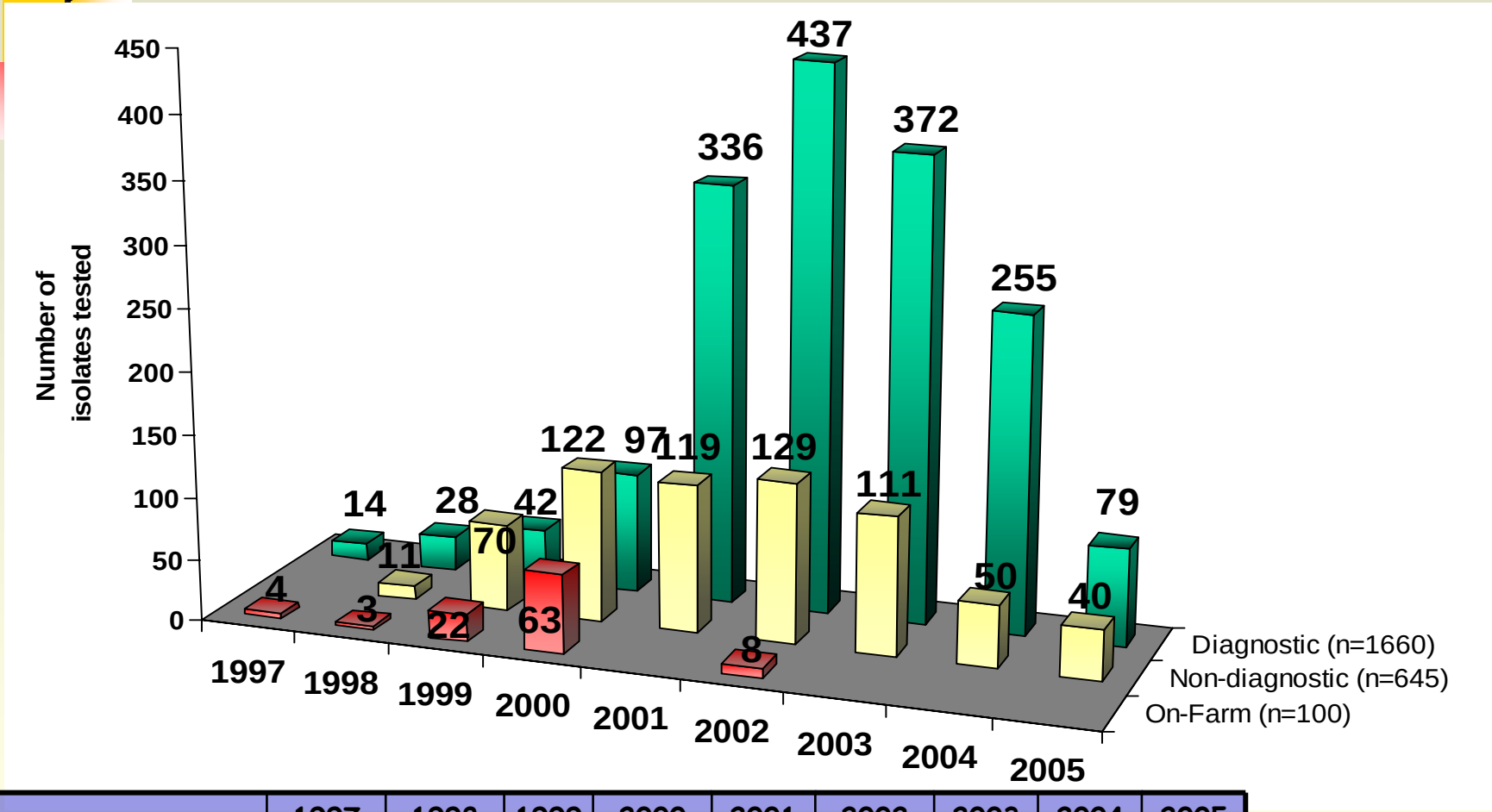
Preliminary data; subject to change; not for public distribution

Kentucky PFGE - Chicken



Preliminary data; subject to change; not for public distribution

Distribution of all *S.* Newport isolates by clinical status: 1997-2005

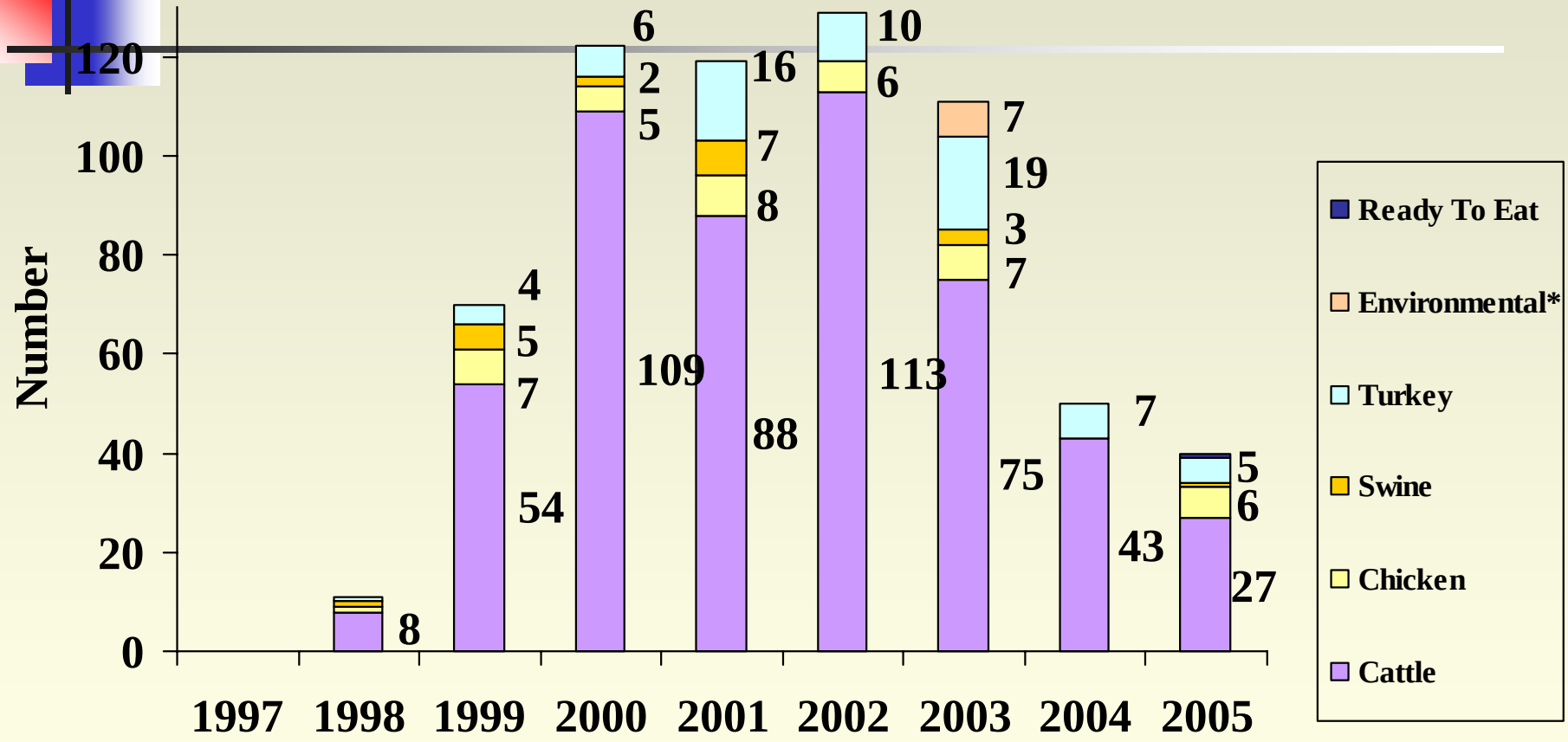


	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total No. of Newports	18	42	134	282	455	574	483	259	119
Total No. of Salmonella	2391	3318	8508	7834	5739	6977	5353	4390	3728
% Newports for year	0.75	1.26	1.57	3.6	7.9	8.2	9.0	5.9	3.2

Animal vs Human

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total No. of Newports	18	42	134	282	455	574	483	259	119
Total No. of Salmonella	2391	3318	8508	7834	5739	6977	5353	4390	3728
% Newports for year	0.75	1.26	1.57	3.6	7.9	8.2	9.0	5.9	3.2
Total No. of Newports	46	77	99	121	124	239	222		
Total No. of Salmonella	1301	1460	1498	1377	1419	2008	1865		
% Newports for year	3.54	5.27	6.61	8.79	8.74	11.90	11.90		

Distribution by source for non-diagnostic S. Newport: 1997-2005

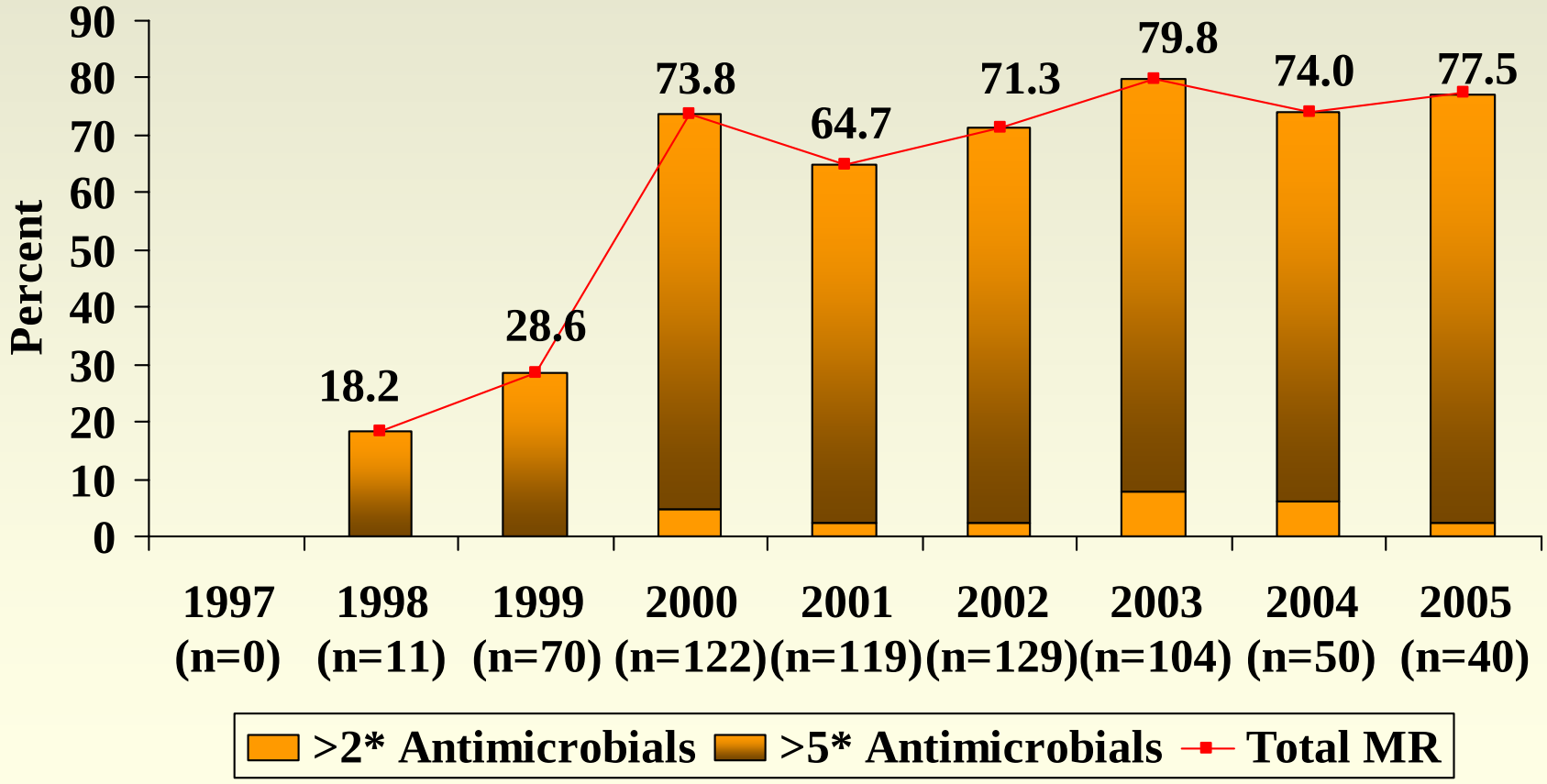


Total non-diagnostic *S.* Newport tested=645

*Poultry production grow-out houses (Note: includes some fecal samples)

Preliminary data; subject to change; not for public distribution

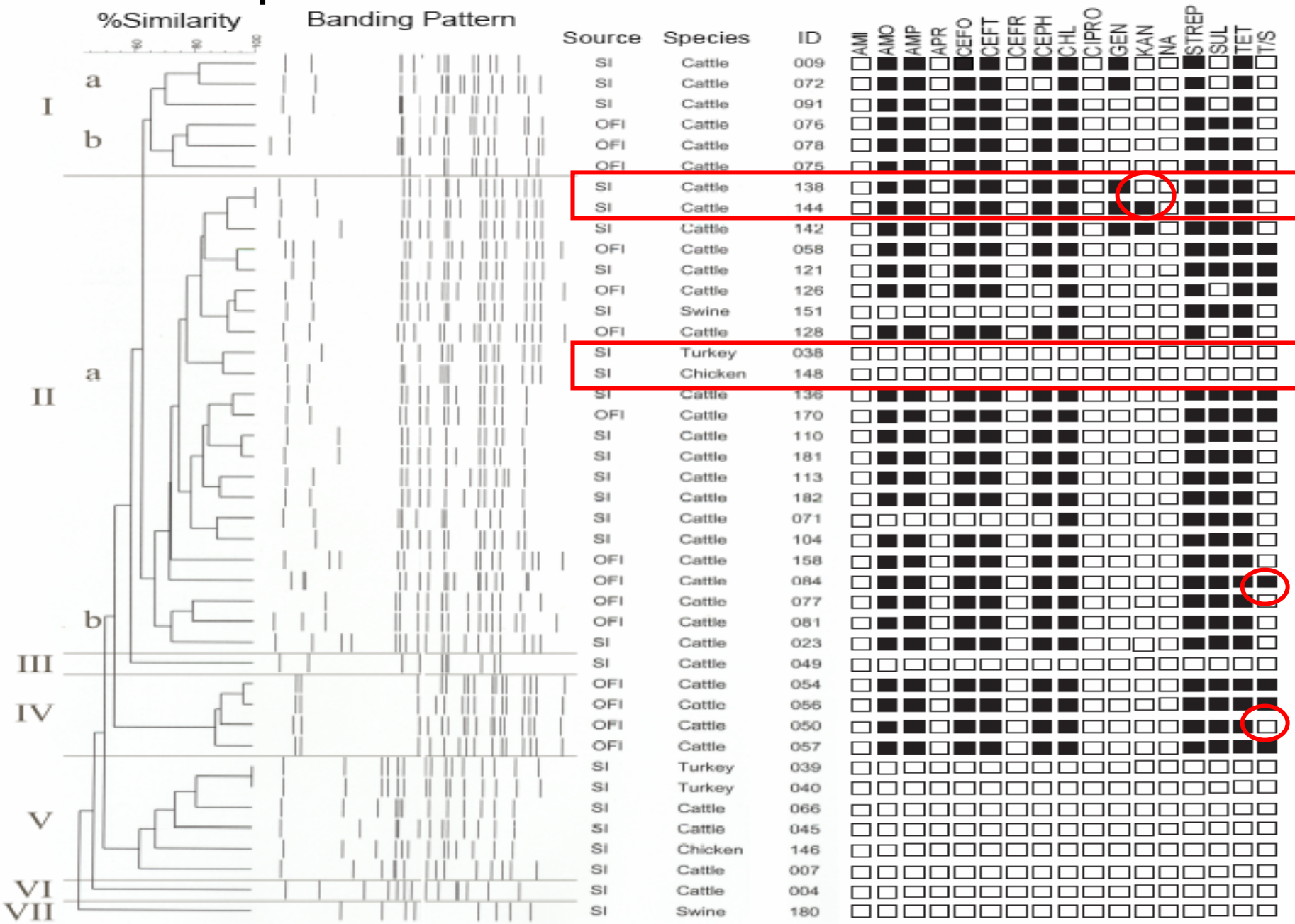
Percent Multiple Resistance *S.* Newport from all slaughter isolates regardless of species



*">" = greater than or equal to

Preliminary data; subject to change; not for public distribution

S. Newport


%Similarity
Banding Pattern
ANTIMICROBIALS
Source
Species
ID
AMI
AMO
AMP
APR
CEFO
CEFT
CEFR
CEPH
CHL
CIPRO
GEN
KAN
NA
STREP
SUL
TET
T/S
I
a
b
II
a
b
III
IV
V
VI
VII
SI Cattle 009
SI Cattle 072
SI Cattle 091
OFI Cattle 076
OFI Cattle 078
OFI Cattle 075
SI Cattle 138
SI Cattle 144
SI Cattle 142
OFI Cattle 058
SI Cattle 121
OFI Cattle 126
SI Swine 151
OFI Cattle 128
SI Turkey 038
SI Chicken 148
SI Cattle 136
OFI Cattle 170
SI Cattle 110
SI Cattle 181
SI Cattle 113
SI Cattle 182
SI Cattle 071
SI Cattle 104
OFI Cattle 158
OFI Cattle 084
OFI Cattle 077
OFI Cattle 081
SI Cattle 023
SI Cattle 049
OFI Cattle 054
OFI Cattle 056
OFI Cattle 050
OFI Cattle 057
SI Turkey 039
SI Turkey 040
SI Cattle 066
SI Cattle 045
SI Chicken 146
SI Cattle 007
SI Cattle 004
SI Swine 180

DT104 Perspective – All Isolates

	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Total no. Tested	2391	3318	8508	7834	5739	6977	5353	4873	3728	48720
Total no. *S.*typh & *S.*tyco	328	557	1562	1308	934	963	944	828	492	7916
% of Total Year	13.7	16.8	18.4	16.7	16.3	13.8	17.6	17.1	13.2	16.2
Total DT104 Suspects**	88	167	560	522	314	321	242	373	136	2723
% of Total Year	3.68	5.03	6.58	6.66	5.47	4.60	4.52	7.7	3.6	5.6
Total DT104 confirmed[b]	60	114	306	280	183	155	114	212	88	1512
% of Total Year	2.51	3.44	3.60	3.57	3.19	2.22	2.16	4.4	2.4	3.1

* All Typh/Tyco w/ACSSuT or ACSuT

Preliminary data; subject to change; not for public distribution

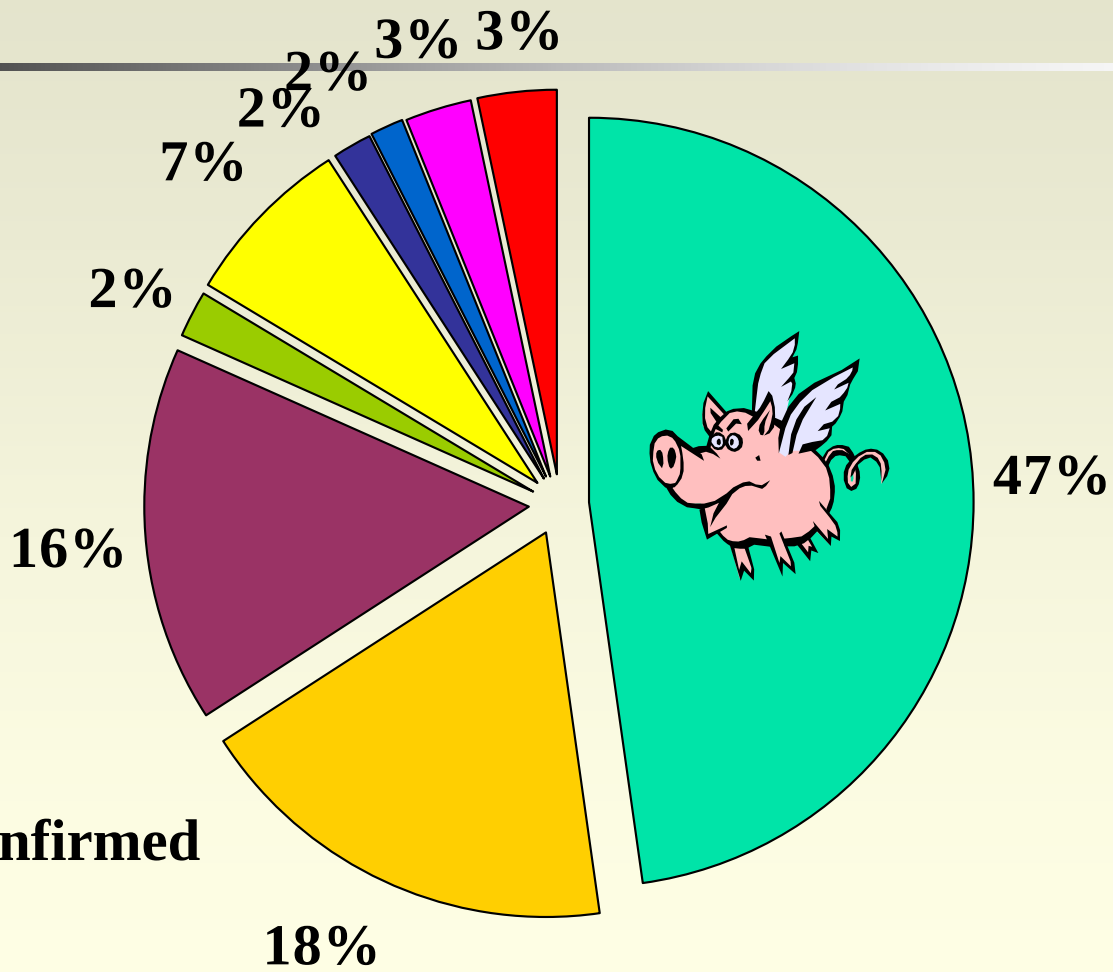
DT104 Perspective – All Isolates

	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Total no. Tested	2391 1301	3318 1460	8508 1498	7834 1377	5739 1419	6977 2008	5353 1865	4873	3728	48720
Total no. *S.*typh & *S.*tyco	328 328	557 377	1562 362	1308 303	934 325	963 393	944 403	828	492	7916
% of Total Year	13.7	16.8	18.4	16.7	16.3	13.8	17.6	17.1	13.2	16.2
Total DT104 Suspects**	88 115	167 120	560 100	522 84	314 96	321 84	242 104	373	136	2723
% of Total Year	3.68 8.84	5.03 8.23	6.58 6.77	6.66 6.10	5.47 6.77	4.60 4.18	4.52 5.58	7.7	3.6	5.6
Total DT104 confirmed[b]	60	114	306	280	183	155	114	212	88	1512
% of Total Year	2.51	3.44	3.60	3.57	3.19	2.22	2.16	4.4	2.4	3.1

* All Typh/Tyco w/ACSSuT or ACSuT

Preliminary data; subject to change; not for public distribution

Total confirmed DT104 by source 1997-2005



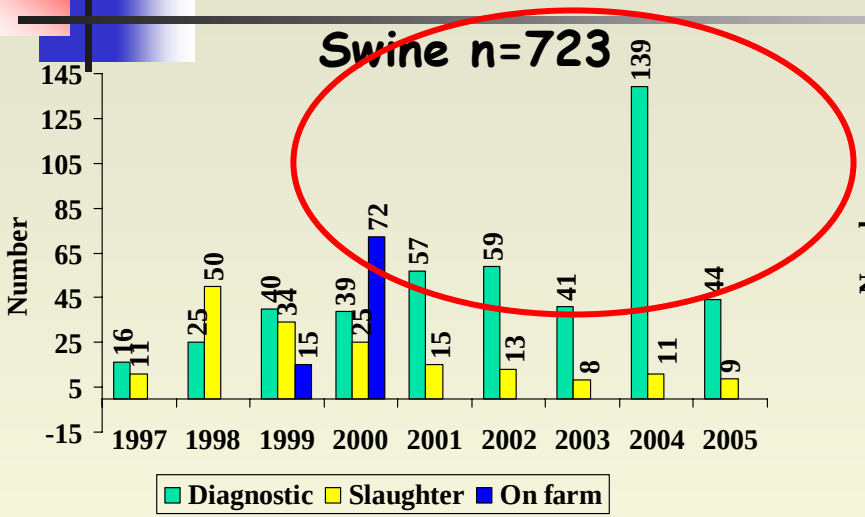
- Swine
- Cattle
- Dairy Cattle
- Cat
- Chicken
- Dog
- Turkey
- Horse
- Other

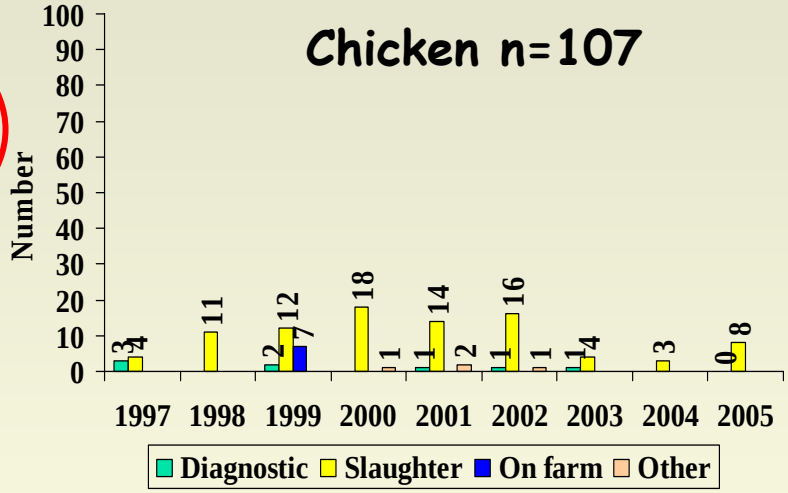
Total =1512 confirmed

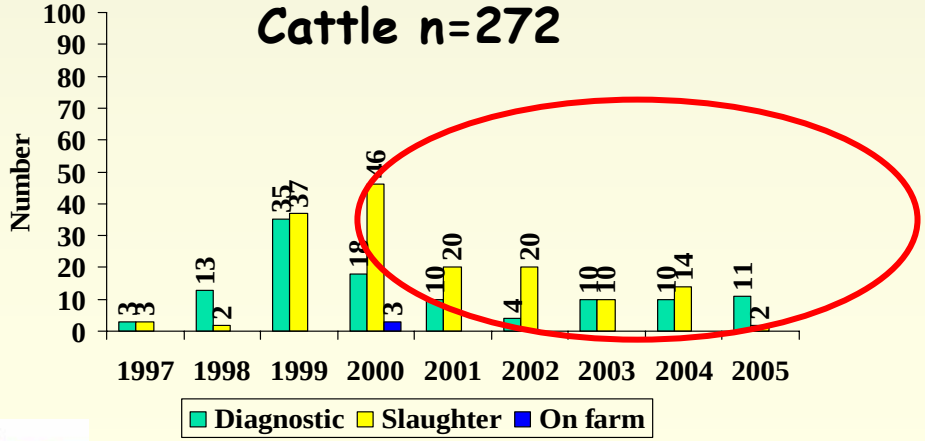
*DT104+ complex A,B & C.

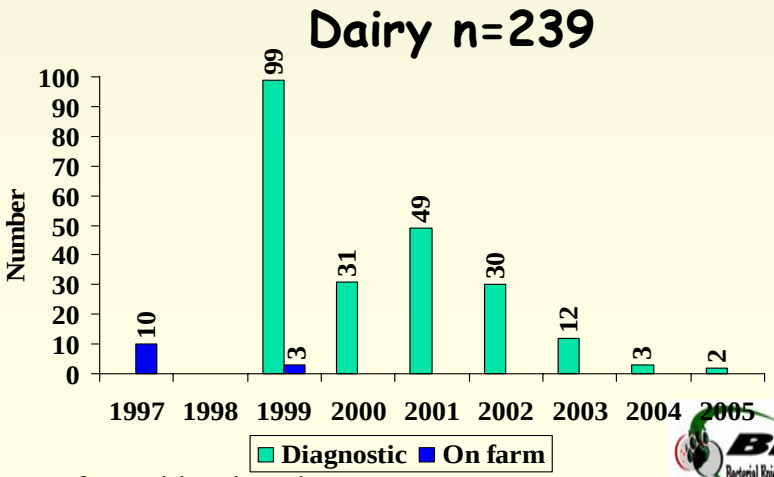
Preliminary data; subject to change; not for public distribution

DT104 by source[a]









[a] DT104 + complex A,B & C

Preliminary data; subject to change; not for public distribution

Phage type – Chicken (regardless of clinical status)

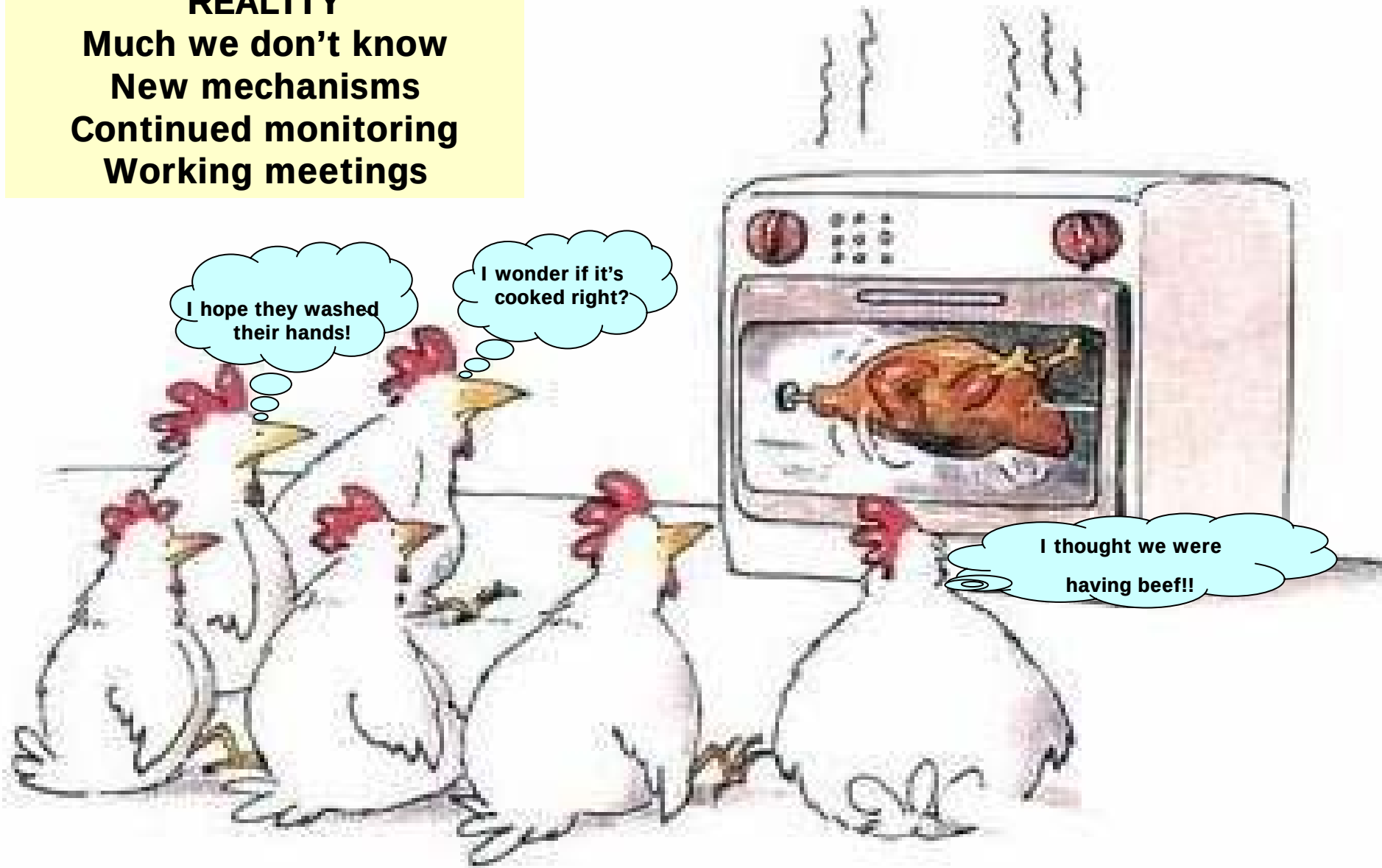
Chicken						
1997 n=7	1998 n=11	1999 n=25	2000 n=22	2001 n=18	2002 n=27	2003 n=7
DT104 N=7	DT104 N=9	DT104 N=19	DT104 N=12	DT104 N=7	DT104 N=17	DT104 N=3
	DT104A N=2	DT104A N=1	DT104A N=3	DT104A N=8		DT104A N=2
		DT104B N=1	DT104B N=4	DT104B N=2	DT104B N=1	
		104L N=1				
					DT12 N=1	
		DT120 N=1			DT120 N=1	
			DT126 N=1			
			DT193 N=1	DT193 N=1	DT193 N=1	
		DT208 N=1			DT208 N=2	
					DT65 N=1	
		DT1 N=1				
			U302 N=1		U302 N=1	
					Untypable n=2	Untypable n=2

Preliminary data; subject to change; not for public distribution

Musings

- What do the differences between serotypes mean?
  - +/- plasmids?
  - =/- genes?
- Should we concentrate on only those that can be identified during an outbreak?
- What about antimicrobial phenotypes?
  - Is a susceptible isolate with a R gene the same as a R isolate if the PFGE is the same?
- Is serotype affecting our ability to further reduce *Salmonella* levels?
  - Or are there other factors?
- What does 'clonal' really mean?

REALITY
Much we don't know
New mechanisms
Continued monitoring
Working meetings



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