

Whole Genome Sequencing for National Surveillance of Enteric Pathogens

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WGS for Enteric pathogen surveillance

Wadsworth: 2012 acquires its first bench top sequencer

- pilot studies with Salmonella Enteritidis
- FDA: 2013 GenomeTrackr initiative.
 - Surveillance of Environmental pathogens
- CDC: 2014 Advanced Molecular Detection initiative.
 - Surveillance of Clinical pathogens

NCBI: creates public databases to hold NGS data.

- Pathogen Detection Portal







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For Salmonella Enteritidis (SE) Outbreak clusters are hard to detect using PFGE

- 50% of the isolates we receive have the same PFGE DNA fingerprint.
- And 2/3 have a very common PFGE DNA fingerprint.
- These **Endemic** types are of limited use to our epidemiologists.



SNP and wgMLST analysis

SNP



wgMLST



Compare single nucleotides (SNPs)

- Highest resolution
- Typing nomenclature is not possible

Compare gene by gene (alleles)

- Lower resolution
- But typing nomenclature is possible

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Salmonella phylogenetic tree



- <u>Branch points</u> indicate putative common ancestor.
- <u>Sum of Horizontal lines</u> measure genetic closeness.

- Tree reveals
 - Genetic closeness
 - Ancestral relationships





Prison outbreaks in Virginia and New York

- **5/16-Virginia** reports an SE outbreak associated with a correctional facility.
- At the same time **NYS** is investigating a SE outbreak also associated with a correctional facility.
- Both have the same PFGE pattern: JEGX01.0021
- Q. Could they be from a common source?



Prison associated cluster



- Clusters were distinct.
- Suggest different source for each outbreak.



Cluster Thresholds that Trigger a Report to NYS Epidemiologists

Organism	Min # isolates	Timeframe	Alleles or SNPs
Listeria monocytogenes	2	Indefinite	20
E. coli	2	1 year	10
Salmonella other serovars	2	60 days	10
S. Enteritidis, Typhimurium & Newport	3	60 days	5

Thresholds as of Oct 2019 We have made 6 revisions since May 2019



3 case studies

- *Listeria monocytogenes* food preparation facility
- *E. coli* O103 NYS geographical cluster
- Salmonella Enteritidis The cluster that never ends



Intermittent Listeria outbreak

From June. 2014 to Oct. 2017

- 13 isolates with matching PFGE were detected
- NY residents were from the same counties
- Based on 120 day time frame- treated as 3 separate clusters
- But should they really be considered as one cluster?



wgMLST analysis shows all are 0 to 6 alleles apart

		WGS ID	Iso Date	Outbreak	Ascl Pattern	Apal Pattern	SourceType
	<u> </u>	PNUSAL002709	2016-11-04		GX6A16.0677	GX6A12.0770	Human
		PNUSAL001130	2014-10-19	1410NYGX6-1	GX6A16.0677	GX6A12.0770	Human
		PNUSAL000888	2014-06-17	1410NYGX6-1	GX6A16.0677	GX6A12.0770	Human
		PNUSAL000806	2014-06-02	1410NYGX6-1	GX6A16.0677	GX6A12.0770	Human
		PNUSAL002802	2017-01-04		GX6A16.0677	GX6A12.0770	Human
0-6		NY81406936	2017-10-10	OMS201715450	GX6A16.0677	GX6A12.0770	Environmental
alleles		PNUSAL003099	2017-05-30		GX6A16.0677	GX6A12.0770	Human
		PNUSAL002278	2016-06-23		GX6A16.0677	GX6A12.0770	Human
		NY81406896	2017-10-10	OMS201715450	GX6A16.0677	GX6A12.0770	Environmental
		NY81406716	2017-10-10	OMS201715450	GX6A16.0677	GX6A12.0770	Environmental
		NY81406976	2017-10-10	OMS201715450	GX6A16.0677	GX6A12.0770	Environmental

- The 2 out-of-state isolates did **not** matched cluster.
- The 4 environmental samples were also closely related



Surveillance and environmental sampling continued

		WGS ID	Isolation Date	Source Type
	, I	PNUSAL004689	2018-12-30	Human
		NY99570229	2019-02-11	Environmental
		NY99541573	2019-02-11	Environmental
		NY99541318	2019-02-11	Environmental
		NY99293701	2019-01-29	Environmental
		PNUSAL000806	2014-06-02	Human
16		PNUSAL000888	2014-06-17	Human
-10		PNUSAL001130	2014-10-19	Human
lleles –		PNUSAL002709	2016-11-04	Human
licico		PNUSAL003099	2017-05-30	Human
		NY81406976	2017-10-10	Environmental
		PNUSAL002802	2017-01-04	Human
		NY81406936	2017-10-10	Environmental
		NY100638542	2019-03-11	Environmental
		PNUSAL002278	2016-06-23	Human
		NY81406716	2017-10-10	Environmental
		NY81406896	2017-10-10	Environmental
		PNUSAL004103	2018-06-27	Human
		NY102159252	2019-04-17	Environmental

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- In 2018 and 2019
 - 2 patient
 - 6 environmental
- Remediation of the facility was undertaken
- After March 2019 no more positive environmental or clinical specimens
- But were there out of state isolates?



Health > Pathogen Detection

Pathogen Detection **BETA**

View the recent webinar: '<u>Introducing the Pathogen Detection Isolates</u> Browser'.

NCBI Pathogen Detection integrates bacterial pathogen genomic sequences originating in food, environmental sources, and patients. It quickly clusters and identifies related sequences to uncover potential food contamination sources, helping public health scientists investigate foodborne disease outbreaks.

Find isolates now!

Examples:

 Search for isolates encoding a mobile colistin resistance gene and a KPC beta-lactamase search: <u>AMR_genotypes:mcr* AND AMR_genotypes:blaKPC*</u>
Search for Salmonella isolates from the USA search: <u>geo_loc_name; USA AND taxgroup_name;"Salmonella enterica"</u>

Explore the Data

Species	New Isolates	Total Isolates
Salmonella enterica	1	<u>237,921</u>
E.coli and Shigella	<u>36</u>	<u>89,268</u>
Campylobacter jejuni	<u>61</u>	<u>45,289</u>
Listeria monocytogenes	2	28,956

NCBI Pathogen Detection

- All Genometrakr and PulseNet samples end up here.
- NCBI builds trees daily for Enteric pathogens.
 - 29,000 *Lm* samples
 - 2,548 Lm trees
- Easily accessed through a web portal.



NCBI Pathogen Detection shows no closely related out of state isolates

 clinical, 2019-01-22 4 environmental/other, environmental, 2019-02-26 environmental/other, environmental, 2019-02-26 environmental/other, environmental, 2019-02-26 environmental/other, sponge, 2019-02-15 environmental/other, environmental swab, 2017-11-02 clinical, blood, 2017-06-30 clinical, blood, 2016-12-06 environmental/other, environmental swab, 2017-11-02 environmental/other, sponge, 2019-05-06 environmental/other, sponge, 2019-03-28 environmental/other, environmental swab, 2017-11-02 clinical, blood, 2016-07-20 environmental/other, environmental swab, 2017-11-02 clinical. 2017-01-30 clinical, blood, 2014-07-20 clinical, blood, 2018-07-25 clinical, blood, 2014-09-01 clinical, blood, 2015-01-12

- All isolates fell into a single NCBI tree.
- No other isolates on the tree.
- 0 to 13 SNPs

And so were not closely related to 29,000 other *Lm*



So how is this working with *Listeria monocytogenes*?

Pretty Good

Improved resolution of WGS allowed:

- Identification of a long term source of *Lm* contamination
- Exclusion of out of state samples
- Able to accurately track remediation
- No additional isolates were detected nationally
- Supports allele range of 0-20
- Supports time frame of forever



NYS E. Coli O103 cluster

From July,11 to Oct 7, 2019

- 20 isolates within a single genomic cluster (0-20 alleles) were detected.
- No PFGE was done
- Epidemiology supported two origins- Western NY and the Metro area.
- Some Metro isolates were associated with kosher food consumption.



cgMLST allele analysis



- 0 20 alleles
- One sub-cluster with 1-8 alleles; associated with kosher food consumption
- cgMLST did not support geographic clustering



SNP Analysis is similar but different



0.02

- 2-61 SNP diversity
- One sub-cluster with 3-15 SNP diversity
- SNP analysis supported geographic clustering



NCBI Pathogen detection



- 2 51 SNPs overall
- One sub-cluster 2-15 SNPs
- SNP analysis supported geographic clustering
- WNY interspersed among many other isolates



Comparing Allele vs SNP trees

Type of tree	Full diversity	Sub-cluster
CGMLST	0-20 alleles	1-8 alleles
FDA SNP	2-61 SNPs	3-15 SNPs
NCBI SNP	2-51 SNPs	2-15 SNPs

- Alleles underestimate full diversity.
- Structure of the allele tree less concordant with epi. data.
- When resolution is needed SNP trees should be built.



So how is this working with STEC?

Pretty good but

In this case cgMLST was discordant with geography

• SNP tree was concordant and had higher resolution

Demonstrated need to rethink cluster reporting thresholds for STECs

- reduce allele or SNP diversity
- shorten timeframe



The Salmonella Enteritidis cluster that won't stop

100 043016-03 JCG 043019-02 0/01/10/00 17 22 3 0 1 0 JEG 043019-02 FN01540077209 100.063019.02 0.70 59/50000179 2010/06/2019 02 1900039825.01.0 NUSAS06486 EG 043019-02 i0/81600042257.01.0 03 6430 19-02 012019-022 08193033875-01-00 PNU5450545 100 043019 02 10/11/00/037454.01.00 PNUMA001721 300.063019.02 11000005521.01 PAULINAD OR 111 100.063079.02 PINUSASIO 147 100 043016-03 R 15000 16 145.01 0 818200 100081100 PAULICALOREMON JCG 043019-02 11600011636.01 DR1600017743-01-0 PNU5450722 JEG 043019-02 R1900019708-01-0 09 042019-02 PNU54507727 DAL HARON BAR 100.003019.02 In 20 a state from the 100.003039.02 JOS M 1019-01 IDR1900042431-01-01 105 043019-02 R1900019086-01-0 EG 042019-02 81900020625-01-0 00.063019.02 11000033533.01.01 PARTICULARIES 100.003019.02 PARTICULAR OF LONG 100.053019.02 081600039503-01-00 JEIS 045019-02 JDD 042019-02 011900018157-01-0 JEG 043019-02 PNU5A509139 100-043019-03 100 043019 03 DR1900041157-01-00 PNUSA5067774 JEG 042019-02 105 010019-02 R1900034562-01-00 JEG 082019-02 81500035405-01-00 100.043019.02 19400319210101 PNU5450617 109-943019-02 11600031922.01.0 PNU64506171 JEG 963019-02 105 ALM16.01 IDR1900042435.01-00 PNUSAS066773 JEG 043019-02 R1600008356-01 PNU3A9009219 JEG-042019-02 PNUMADORNAL 100 063019-02 110000393099.01.0 100 043019-02 R 1900025813-01-0 PARISAS DE 1465 JEG 041019-02 100.00310.003 DR1900039827-01-00 .00 043019-02 DR160000386-01 PNU554506734 303 043019 03 DR 1900032778-01-0 NUSAS01248 0.010019-0 DR1900039577-01-01 JDD 043019-03 JEG 043019-02 JEG 082019-02 108190000002.01.00 PROVIDED THE PRO 100.043039.02 DR1900040307-01-00 PNU5450603 JEG 043019-02 DR 19000 1331 2-01 JEG-013039-03L DR1600028875-01-0 CG 043019-03 DR 1900030102-01-00 PNUSAS07996-JEG 043019-02 DR1900032386-01-0 07190037040-01-00 PNU5A5091711 JCG 043019-02 PNU54509452 JCG 013019-02 081900021207.01.01 R1900031082-01-0 JEG 043019-03 NUSA506076 DR1600035707-01-0 PNUSA509139 JEIG 043019-02 JEG 043019-03 100.043019-02 IDR1900011947-01 JCG 013019-02 JEG 043019-03 R1600036833-01-0 JEIS 045019-02 JEG 042019-02 R1000030520010 110 8160004056450010 100-043019-02 100 043019-02 100.013119.03 JDR1600042196-01-00 JEG 045019-02 100 010019-02 DR1900039823-01-00 JEG 042019-02

WHITE IT CONTR

From 4/30/19 to 10/08/19 we sent **8** seperate reports tracking a single cluster to our epidemiologists.

- The cluster eventually contained 84 patient samples.
- With no strong epidemiological links.
- 0-11 allele diversity.
 - Why is the cluster allele diversity greater than 5?



woM	E.	OT.	(Core)	

	IDR 1900029494-01-00	PNUSAS079948	JEG 043019-02
	IDR1900039219-01-00	PNUSAS094248	JEG 043019-02
0.000	IDR 19000 1351 1-01	PNUSAS070782	JEG 043019-02
60 (K. 2)	IDR 19000 17223-01-00	PNUSAS072103	JEG 043019-02
	IDR1900027216-01-00	PNUSAS077269	JEG 043019-02
	1DR190003/942/01-00	PNUSAS092220	JEG 043019-02
10.0.2	IDR 190003922501-00	PNUSAS094062	JEG 043019-02
	IDR 1900003589-01	PNUSAS087599	JEG 043019-02
100.00	IDR 1900033845-01-00	PNUSAS083445	JEG 043019-02
	IDR 1900033875-01-00	PNUSAS083450	JEG 043019-02
1.0 (0.2)	IDR 1900037484-01-00	PNUSAS091720	JEG 043019-02
100.2	IDR 190000552 1-0 1	PNUSAS068138	JEG 043019-02
	IDR 19000 16 145-01-00	PNUSAS071471	JEG 043019-02
	IDR 1900036791-01-00	PNUSAS090134	JEG 043019-02
	IDR1900044382-01-00	PNUSAS 103675	JEG 043019-02
	IDR1900009110-01	PNUSAS069217	JEG 043019-02
	IDR 19000 1038 9 0 1	PNUSAS070074	JEG 043019-02
	IDR 19000 17743-01-00	PNUSAS072297	JEG 043019-02
	IDR 19000 19706-01-00	PNUSAS073477	JEG 043019-02
	IDR 1900027220-01-00	PNUSAS077270	JEG 043019-02
	IDR 1900028297-01-00	PNUSAS078989	JEG 043019-02
200.3	IDR 1900036644-01-00	PNUSAS091397	JEG 043019-02
	IDR 1900040459-01-00	PNUSAS096582	JEG 043019-02
0.000	IDR1900042431-01-00	PNUSAS099774	JEG 043019-02
0.00.20	IDR 19000 18086-01-00	PNUSAS072663	JEG 043019-02
	IDR 1900020620-01-00	PNUSAS073870	JEG 043019-02
1.462	IDR 1900033530-01-00	PNUSAS083434	JEG 043019-02
200.0 400.0	DR1900039583-01-00	PNUSAS094524	JEG 043019-02
149.2	IDR 19000 17 990-01-00	PNUSAS072662	JEG 043019-02
146.2	IDR 19000 18 157-0 1-00	PNUSAS073457	JEG 043019-02
140.2	IDR 1900036673-01-00	PNUSAS091398	JEG 043019-02
	IDR1900039258-01-00	PNUSAS098838	JEG 043019-02
1.00.11	IDR 1900041 157-01-00	PNUSAS097774	JEG 043019-02
	IDR1900041719-01-00	PNUSAS099749	JEG 043019-02
	IDR 1900034062-01-00	PNUSAS084622	JEG 043019-02
	· IDR 1900031931.01.00	PNUSAS090127	JEG 043019-02
	IDR1900031922.01.00	PNUSAS081716	JEG 043019-02
	IDR1900038353-01-00	PNUSAS092230	JEG 043019-02
2.010.00	IDR1900042430-01-00	PNUSAS099773	JEG 043019-02
10(0.2)	IDR 1900009356-01	PNUSAS069219	JEG 043019-02
	IDR 19000 1091 2-01	PNUSAS069640	JEG 043019-02
	IDR 19000 18389-01-00	PNUSAS072669	JEG 043019-02
100.0	IDR1900025813-01-00	PNUSAS077246	JEG 043019-02
10(0.2)	IDR1900032342.01.00	PNUSAS091718	JEG 043019-02
	DR1900039827-01-00	PNUSAS098842	JEG 043019-02
129.2	IDR 1900003260-01	PNUSAS067346	JEG 043019-02
2010. Q 1010.2	IDR1900032778-01-00	PNUSAS082463	JEG 043019-02
100.2	IDR 1900039577-01-00	PNUSAS098840	JEG 043019-02
100.0	IDR 1900009029-01	PNUSAS069214	JEG 043019-02
1 192.4	IDR 1900036303-01-00	PNUSAS090125	JEG 043019-02
240.0 147.2	IDR 1900043882-01-00	MUSAS 100750	JEG 043019-02
2010.0	IDR1900013312-01	PNUSAS0/6837 PNUSAS070774	JEG 043019-02
140.1	IDR 1900028870-01-00	PNUSAS079001	JEG 043019-02
200.2	IDR 1900030 102-01-00	PNUSAS079964	JEG 043019-02
349.3	IDR 1900032266-01-00	PNUSAS081724	JEG 043019-02
	IDR 1900037040-01-00	PNUSAS091711	JEG 043019-02
	IDR 1900039746-01-00	PNUSAS094527	JEG 043019-02
30 (6. 7)	IDR 1900021267-01-00	PNUSAS074347	JEG 043019-02
3.0 (0. 7)	IDR 1900031082-01-00	MUSAS080766	JEG 043019-02
3.0 (5. 7	IDR 1900038707-01-00	PNUSAS100122	JEG 043019-02
30 [0.7]	IDR 1900020649-01-00	PNUSAS074339	JEG 043019-02
	IDR 19000 11947-01	PNUSAS070087	JEG 043019-02
an Da - D	IDR 1900031633-01-00	PNUSAS081705	JEG 043019-02
2010 7	IDR 1900034633-01-00	PNUSAS084634	JEG 043019-02
×00.0	IDR 1900030526-01-00	PNUSAS079970	JEG 043019-02
3.0 (0. 6)	IDR 1900043949-01-00	PNUSAS 100754	JEG 043019-02
145.1	IDR 1900038725-01-00	PNUSAS092319	JEG 043019-02
L	IDR 1900039298-01-00	PNUSAS094516	JEG 043019-02
	IDR 1900042 196-01-00	PNIISAS083703	JEG 043019-02
	IDR 1900033313-01-00	PNUSAS(98/41	JEG 043019-02
	10111000000000000000000000000000000000		

The problem of chaining

- New samples are received within 60 days that are within 5 alleles to at least one other sample.
- Clustering criteria are inadequate.
- Overlaying epi. data was not helpful.





And worse at NCBI

- 353 samples within 0 SNPs of this cluster.
- 1645 within 5 SNPs.
- 2375 within 15 SNPs.
- And these numbers are constantly increasing



So how is this working with SE?

	IDR1900029494-01-00	PNUSAS079948	JEG 043019-02
	IDR1900039219-01-00	PNUSAS094248	JEG 043019-02
	IDB 19000 1351 1-0 1	PNUSAS070782	JEG 043019-02
648.2	IDB 19000 1722 3-0 1-00	PNUSAS072103	JEG 043019-02
1	IDR1900027216-01-00	PNUSAS077269	JEG 043019-02
	IDR 1900037942-01-00	PNUSAS092220	JEG 043019-02
0.000.1	IDR 19000 3982 5-0 1-00	PNUSAS094662	JEG 043019-02
100.20	IDR1900042237-01-00	PNUSAS099772	JEG 043019-02
	IDR 1900003589-01	PNUSAS067599	JEG 043019-02
100.00	IDB 1900033845-01-00	PNUSAS083445	JEG 043019-02
	IDR1900033875-01-00	DNUSAS083450	IEG 013019-02
100.2	IDR1900017464-01-00	DNI ISAS091720	IEG 013019-02
	10111000001401 01	DNUE46088138	150 043010 02
1.0(0.2)	IDR 190000021-01	PNUSA5066136	JEG 043019/02
1.00.20	IDR 19000 36 79 1 0 1 00	PNUSAS071471	JEG 043019/02
	IDD1000044383.01.00	DNU IDAD 10/2075	IEC 043019-02
	IDR 1900009 110.01	DNUSAS089217	JEG 043019-02
	IDR 19000 10389-01	DNUSAS089829	JEG 043019-02
	IDR1900011535.01	PNUSAS070074	IEG 043019-02
	IDB 19000 17743-0 1-00	PNUSAS072297	JEG 043019-02
	IDR 19000 19706-01-00	DNI 1949/073/77	IEG 013019-02
	IDR1900037320-01-00	PNUSAS077270	IEG 013019-02
	IDR1900028297.01.00	DNUDAD070000	IEG 013019.02
	IDR 1900036644-01-00	PNUSAS091397	JEG 043019.02
209.3	IDP1900040459-01-00	PNUSAS096582	JEG 043019-02
0.0 (0. 1)	IDP1900042431-01-00	DNI ISAS/000774	IEG 043019.02
	IDD 19000 18086-01-00	DNI ISAS072683	IEG 013019-02
60 p.2	IDD 19000 20820.01.00	DNI ISAS073870	IEG 013019-02
	IDR 1900020820-01-00	PNUSAS073070	JEG 043019/02
	IDR 1900033330 01 00	PNU3A3083434	JEG 043019/02
2010-01 14(6-2)	IDR 1900039583-01-00	PNUSAS094524	JEG 043019-02
14(6,2)	IDR 19000 17990-01-00	PNUSAS072682	JEG 043019-02
14(6.2)	IDR 19000 18 157.0 1.00	PNUSAS073457	JEG 043019-02
140.20	IDR1900036673-01-00	PNUSAS091398	JEG 043019-02
	IDR 19000 39258-01-00	PNUSAS098838	JEG 043019-02
	IDR1900041157-01-00	PNUSAS097774	JEG 043019-02
1400.10	IDR1900041719-01-00	PNUSAS099749	JEG 043019-02
	IDR1900034062-01-00	PNUSAS084622	JEG 043019-02
	IDR1900036460-01-00	PNUSAS090127	JEG 043019-02
0.00.11	IDR1900031921-01-00	PNUSAS081715	JEG 043019-02
	IDR1900031922-01-00	PNUSAS081716	JEG 043019-02
	IDR 1900038353-01-00	PNUSAS092230	JEG 043019-02
20(0,6)	IDR1900042430-01-00	PNUSAS099773	JEG 043019-02
14(6.2)	IDR1900009356-01	PNUSAS069219	JEG 043019-02
	IDR 19000 1091 2-0 1	PNUSAS069640	JEG 043019-02
	IDR1900018389-01-00	PNUSAS072669	JEG 043019-02
1.0 (0.2)	IDR 1900025813-01-00	PNUSAS077246	JEG 043019-02
	IDR 1900030070-01-00	PNUSAS081695	JEG 043019-02
12(6.2)	IDR1900037342-01-00	PNUSAS091718	JEG 043019-02
12(0.2)	IDR1900039827-01-00	PNUSAS098842	JEG 043019-02
100.0	IDR1900003280-01	PNUSAS067346	JEG 043019-02
108.2	IDR1900032778-01-00	PNUSAS082463	JEG 043019-02
	IDR1900039577-01-00	PNUSAS098840	JEG 043019-02
1.0 (0.4)	IDR190009029-01	PNUSAS069214	JEG 043019-02
105.1	IDR1900036303-01-00	PNUSAS090125	JEG 043019-02
240.4	10101900043882-01-00	PN0545100750	JEG 043019-02
	IDR1900042312.01	PNUSAS096637	JEG 043019-02
1.0 (1, 1)	1001000028970.01.00	DNU222070001	JEC 043019-02
	IDR 190002887 010100	DNUEAE070084	JEG 043019-02
300.7 200.2	IDR 1900030102-01-00	DNUSAS081724	JEG 043019-02
	IDR 1900037040-01-00	PNUSAS091711	JEG 043019-02
300.7	IDR 1900039746-01-00	PNUSAS/094527	JEG 043019-02
2007	IDR 1900021267-01-00	PNUSAS074347	JEG 043019-02
30(0, 1)	IDR 1900031082.01.00	PNUSAS080786	JEG 043019-02
2.0 (D. 7	IDR 1900035707-01-00	PNUSAS091393	JEG 043019-02
3.0 (0. 7	IDR 1900042681-01-00	PNUSAS 100 133	JEG 043019-02
30 [0.7]	IDR 1900020649-01-00	PNUSAS074339	JEG 043019-02
3010.7	IDR 19000 11 947-01	PNUSAS070087	JEG 043019-02
	IDR 1900031633-01-00	PNUSAS081705	JEG 043019-02
	IDR 1900034633-01-00	PNUSAS084634	JEG 043019-02
20 <u>1.0</u>	IDR 1900030526-01-00	PNUSAS079970	JEG 043019-02
	IDR 1900043949-01-00	PNUSAS 100754	JEG 043019-02
1.0(0,1)	IDR 1900038725-01-00	PNUSAS092319	JEG 043019-02
	IDR 1900039298-01-00	PNUSAS094516	JEG 043019-02
	IDR 1900042196-01-00	PNUSAS099768	JEG 043019-02
	IDR 1900033313-01-00	PNUSAS083427	JEG 043019-02
	IDR 1900039823-01-00	PNUSAS098841	JEG 043019-02

Not so well for common S. Enteritidis types

Improved resolution was not helpful

- Lab results can not inform epi.
- Yet a huge amount of work.

Solutions for Salmonella

- Consider other parts of the genome.
- Try to identify these common types prior to analysis.
 - then do not analyze unless requested



Where do we stand now?

WGS does improve surveillance.

- More clusters will be identified than with PFGE.
- More sources will be identified.
- And cases of foodborne illness should decline.

But challenges remain

- Too many clusters.
 - Need to prioritize, but how?
 - Refine cluster definitions.
- Identification of endemic clusters.



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Bioinformatics core