Wastewater-based epidemiology in Wales

COVID-19 and beyond

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PRIFYSGOL BANGOR UNIVERSITY

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Wastewater operations and research team

Wastewater monitoring in Wales is operated and funded by Welsh Government
We also acknowledge the support from all our collabrators

Wastewater monitoring in the UK for COVID-19

- Four separate wastewater programmes were operated in the UK in response to the pandemic, across the devolved Governments and by the UK Government in England.
- Health is one of the devolved responsibilities in Wales, Scotland and Northern Ireland.
- Only two programmes are still **actively** sampling on a national level; Scottish Government and Welsh Government.
- All four nations regularly meet, and work closely to share advancements in wastewater surveillance and to help build the long term case for WBE.

Northern Ireland Executive

HM Government

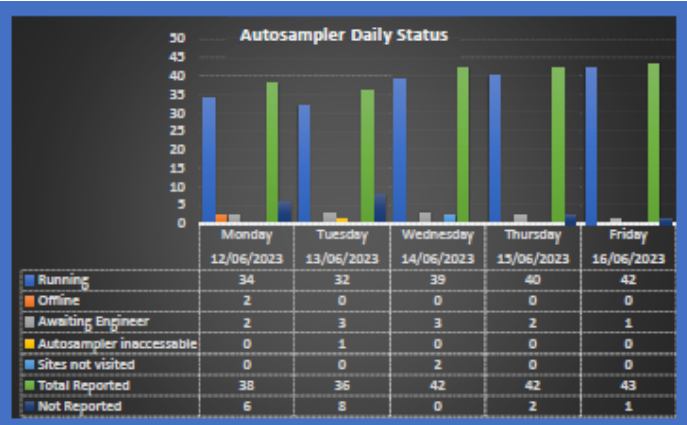
Scottish Government
Riaghaltas na h-Alba

Llywodraeth Cymru
Welsh Government

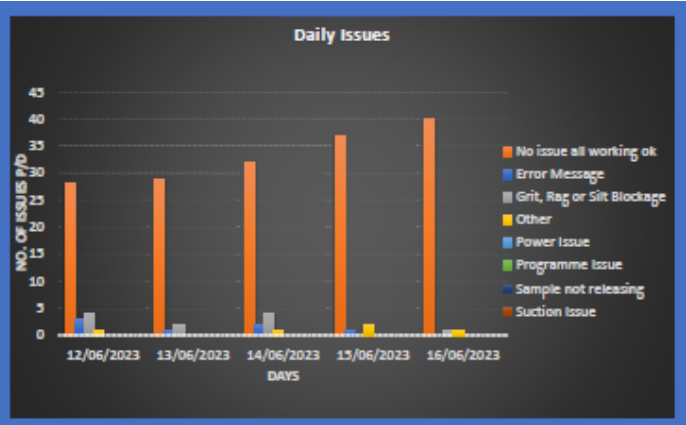
Wastewater monitoring in Wales

- Wales undertakes a comprehensive wastewater monitoring programme across **47 municipal WwTW.**
- 5 days-a-week, 24-hour composites of influent (and some effluents).
- ~75% of Welsh population covered (2.4m people covered). PE values range from 419 to 612,000.
- Sites chosen based on geography and population density.
- Monitoring COVID-19, Influenza, Norovirus, RSV, Enterovirus, Polio and antibiotic resistant genes (ARGs). Policy relevant questions where we can give answers.
- Pilot trials (pharmaceuticals, protozoal pathogens, culturable AMR).
- Running for > 2 years (some sites since March 2020).

Different sampling approaches used in Wales



	Monday 12/06/2023	Tuesday 13/06/2023	Wednesday 14/06/2023	Thursday 15/06/2023	Friday 16/06/2023
Running	34	32	39	40	42
Offline	2	0	0	0	0
Awaiting Engineer	2	3	3	2	1
Autosampler inaccessable	0	1	0	0	0
Sites not visited	0	0	2	0	0
Total Reported	38	36	42	42	43
Not Reported	6	8	0	2	1



- 17 sites missed reporting, 2 reported offline, 11 awaiting Engineer visit, 1 inaccessable and 2 reported by not visited

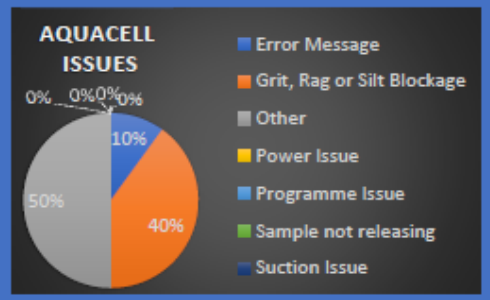
- Long term running % (82) remaind the same, the last 4 week average running % (79) has decreased due to the recent numbers of missed reporting.

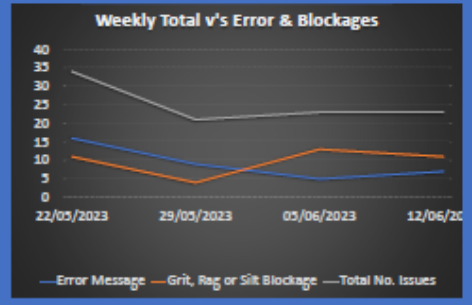
- Out of the 23 issues reported, the drivers were able to resolve 21 of the issues in the first visit.

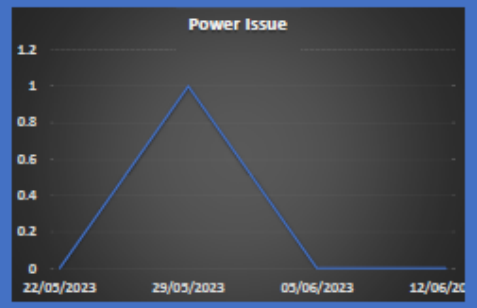
- Total reported issues in the last week have remained the same as the previous week at 23.

- Aquacell 10 issues, 5 (50%) Other issues, 4 Blockages and 1 Error message.

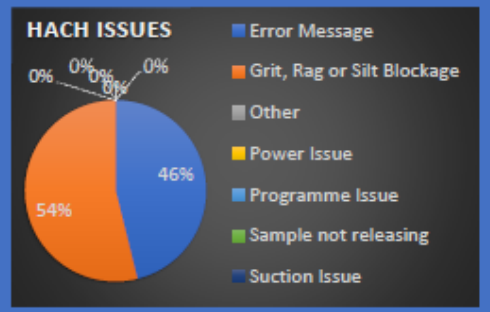
- Hach 13 issues, 7 (54%) Blockages and 6 Error messages.

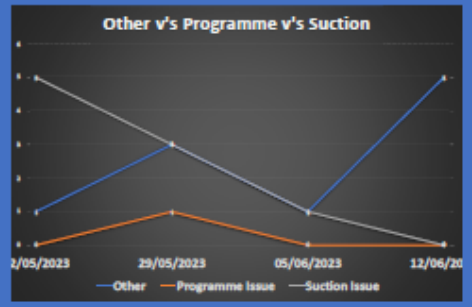


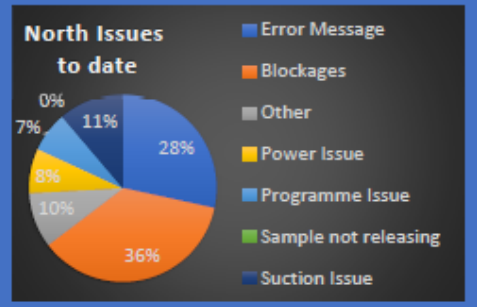


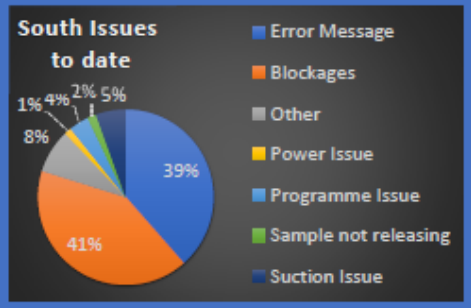


Rolling issues North South Split		
Issues	North	South
Error	33	476
Blockage	42	510
Other	11	100
Power Issues	9	16
Programme Issues	8	45
Sample Not releasing	0	20
Suction Issues	13	68
Total to date	116	1235
Data start date 17th May 2022		



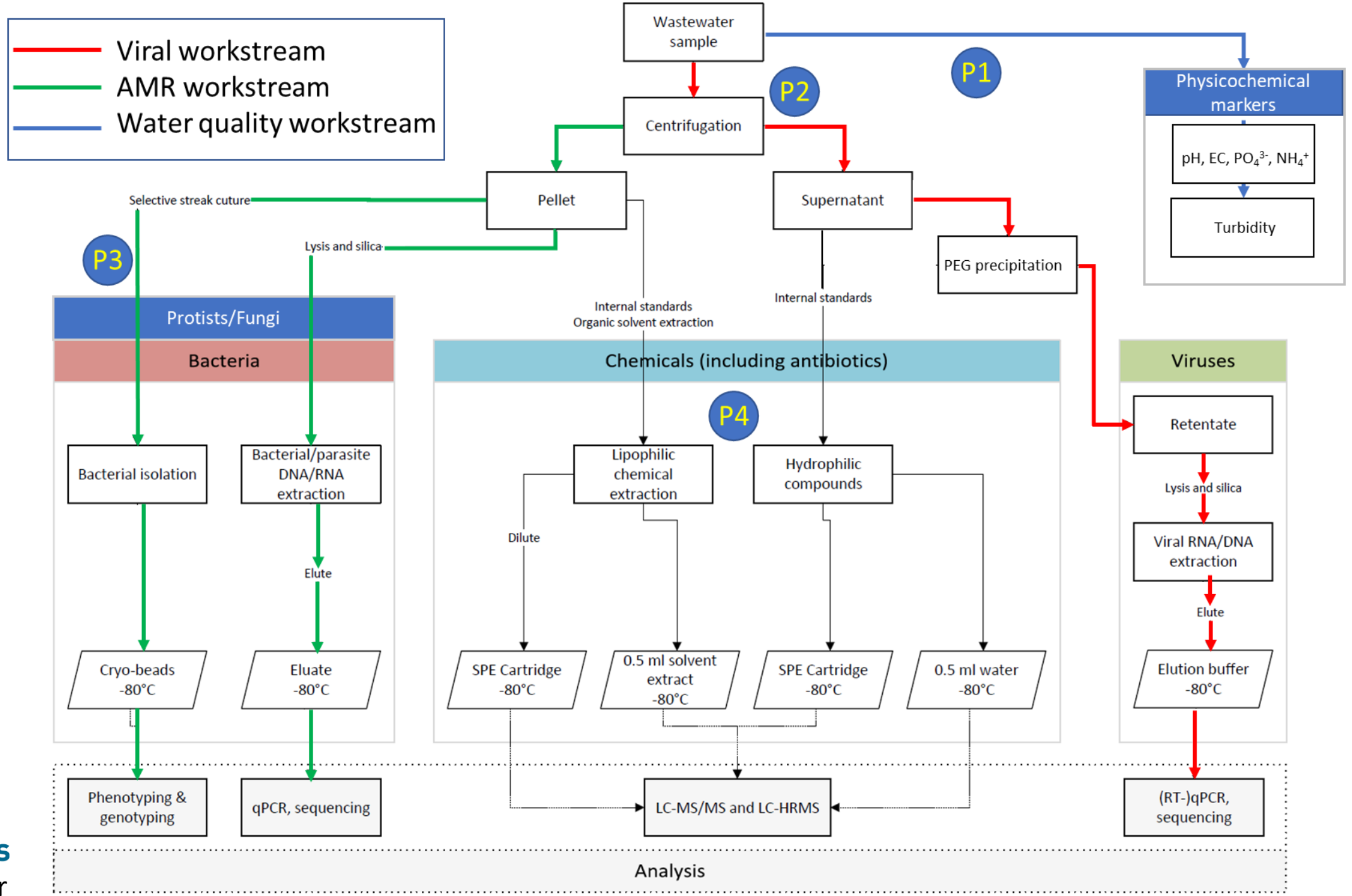






Composite table explanation
- 11 actual no composites
- Remaining entries due to missed reporting, no visits, etc..

Aquamatic Engineer Visits
Cardigan confirmed 11.7.23
Cilfynydd and Pen Y Bont confirmed 27.6.23



Cefas

D. Walker

Weekly reporting of COVID-19 to Welsh Government

Since the last report, SARS-CoV-2 viral load has decreased across the country.
The signal decreased in 13 regions and remained level in 1 region.

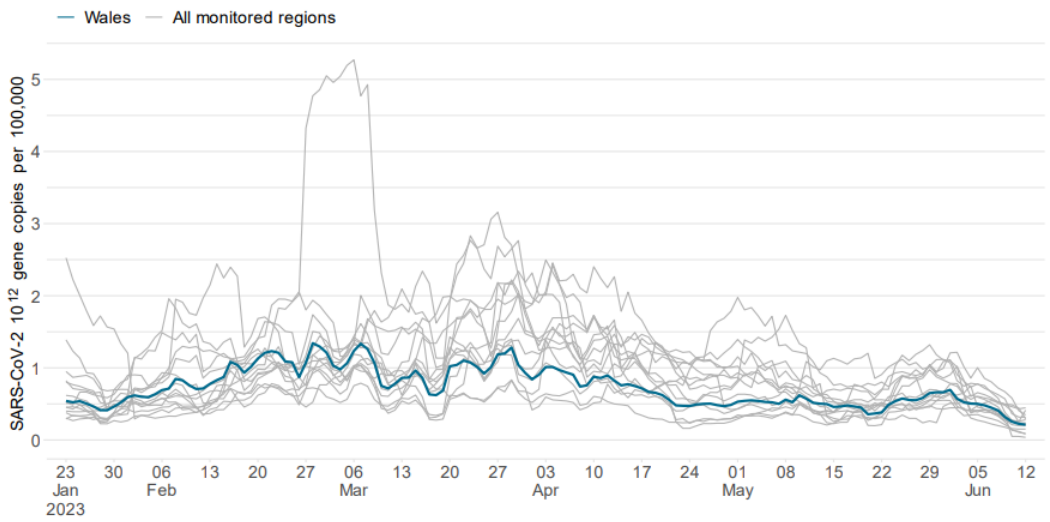


Figure 2 - National (blue lines) and Regions (grey lines)
Rolling Mean SARS-CoV-2 gc/day per 100k

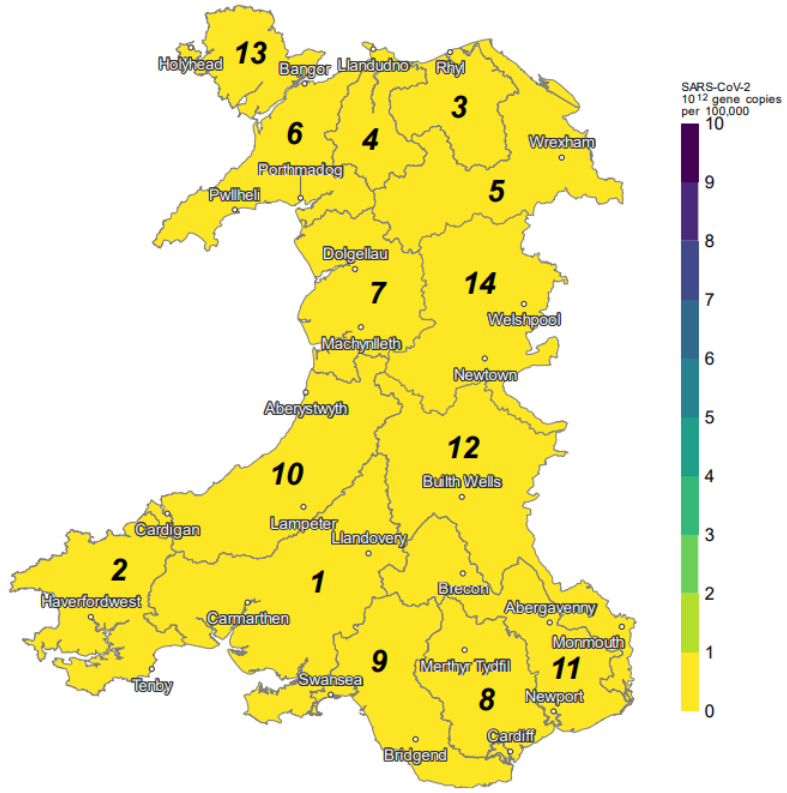
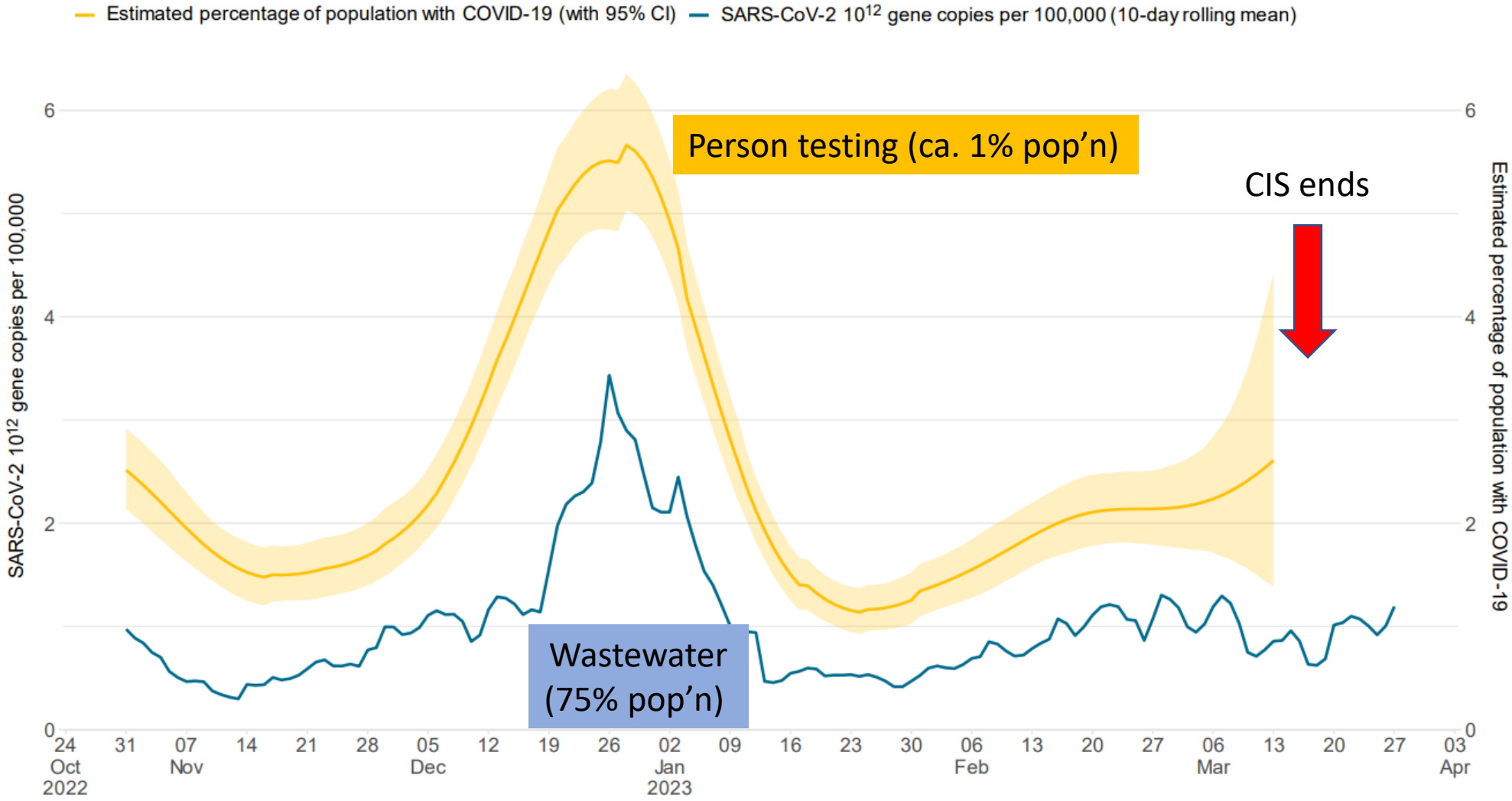


Figure 3 - National Heat Map showing Regional
Mean SARS-CoV-2 gc/day per 100k

Wastewater vs. COVID-19 Infection Survey in Wales



SARS-CoV-2 mapped weekly

thebmj

News

Covid-19: What do we know about XBB.1.5 and should we be worried?

BMJ 2023 ; 380 doi: https://doi.org/10.1136/bmj.p153 (Published 19 January 2023)
Cite this as: *BMJ* 2023;380:p153

Article | Related | Metrics | Responses

Elisabeth Mahase

Author affiliations

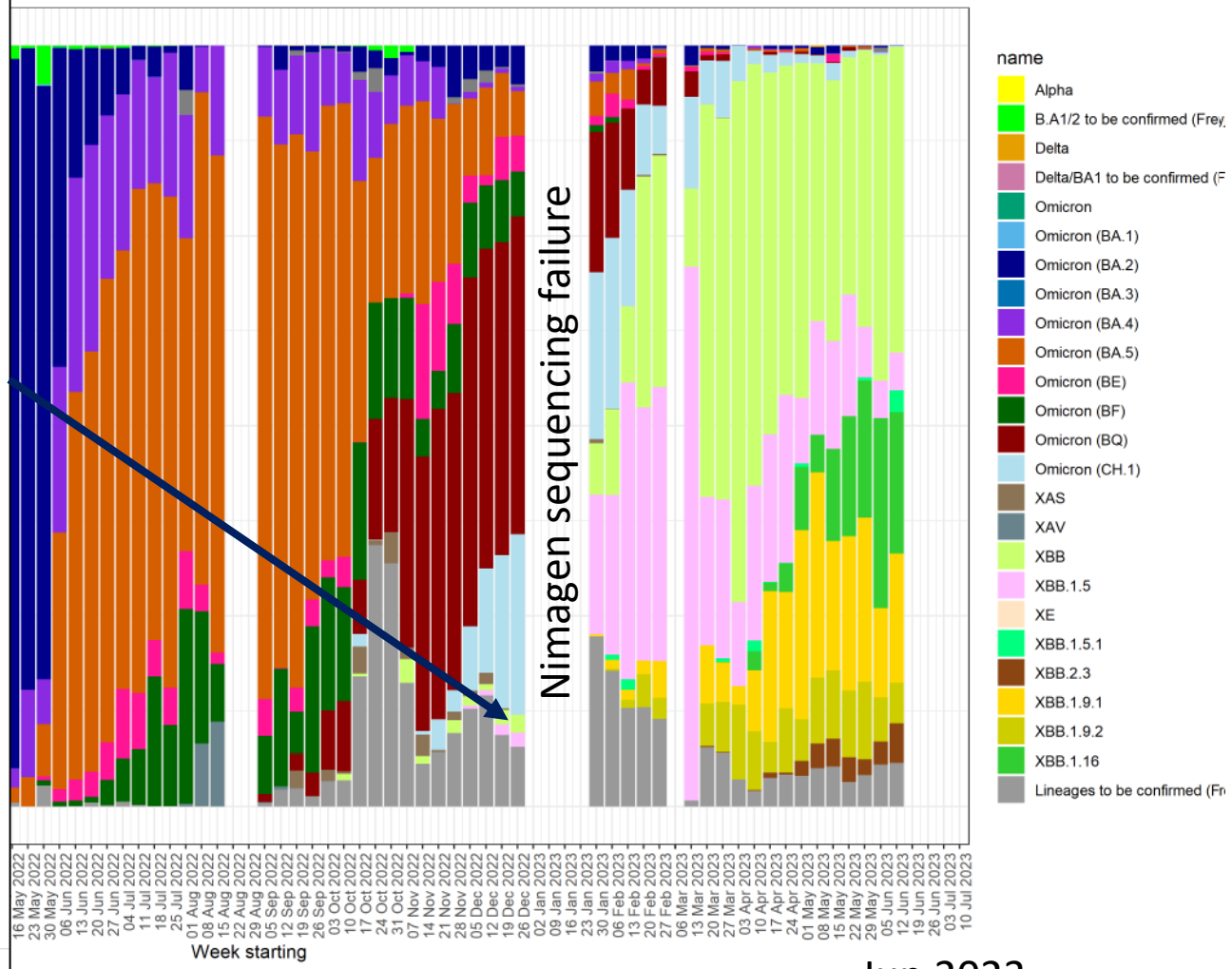
The XBB.1.5 omicron variant of SARS-CoV-2 has been making headlines for weeks. **Elisabeth Mahase** reports what we know so far

What is XBB.1.5?

XBB.1.5 is yet another omicron subvariant, and follows on from XBB and XBB.1. Scientists have nicknamed it "kraken" to distinguish it from the "variant soup" we are all navigating three years into the pandemic.[1] The X signifies that these subvariants came about through a recombination of two or more sublineages—in this case BA.2.10.1 and BA.2.75.[2]

According to UCL Genetics Institute director Francois

bmj.com



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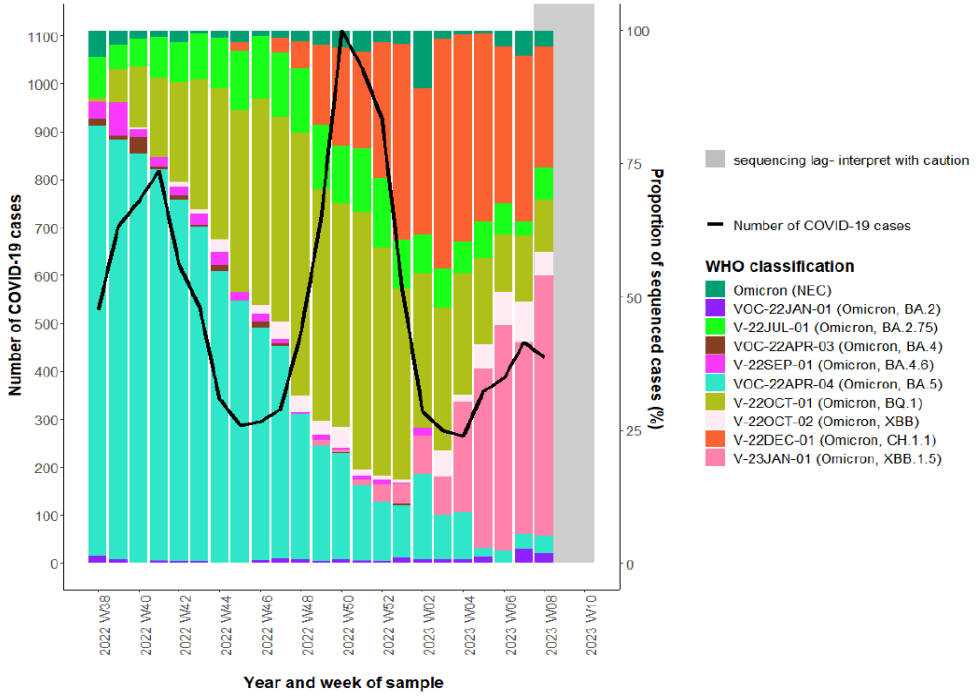
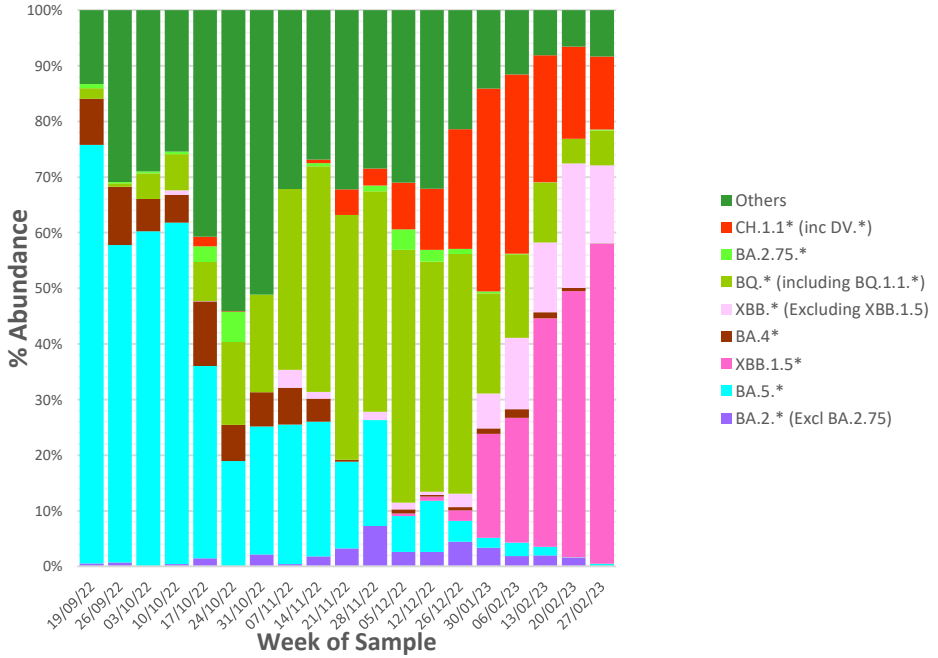




Top: Sequenced Cases (Hospital and Care settings)

Bottom: Wastewater Sequencing

- Some variation expected as wastewater bioinformatics differs to the clinical pathway.
- Despite different approaches and different sampling methodology there is similarity.
- Wastewater sequencing generally reports a week ahead of sequenced cases and does not have sequencing lag.
- **Conclusion: wastewater sequencing was a reliable source of variant abundance and growth data but low abundance detections in isolation should be treated with caution/discounted.**

Case Study – Winter 2021/22

- Omicron (VOC-21NOV-01 B.1.1.529) detected on 24th November 2021 on GISAID.
- Rapidly developed SNP assay (developed in co-op with the 4N) gave indicative detections of Omicron in Wales' wastewater from as early as 15th November.
- SNP and wastewater data used in intelligence cell discussions to illustrate the growth of Omicron in Wales. Data contributed to the scientific advice used to inform the Boxing day "alert level two" decision.
- Wastewater SNP assay data and wastewater signal data used as one of the primary intelligence sources for the decision to move out of Alert level 2 and into Alert Level 0 due to the lag in other data sources.

Case Study – Winter 22/23

- BQ.1 was growing steadily with little immediate impact on hospitalisations.
- CH.1.1 had been detected since late October but started to grow quickly in late November.
- Sudden sharp increase in hospitalisations driven primary by BQ observed.
- Policy modelling for potential impact on hospitalisations as a result of CH.1.1 wave conducted due to concern over additional COVID-19 pressures on top of other acute respiratory viruses - utilised wastewater sequencing data in isolation.
- Wastewater signal data gave evidence of a short sharp wave, no national policy changes occurred with regard to COVID-19 controls with only local NPIs being put in place at the discretion of local health boards.

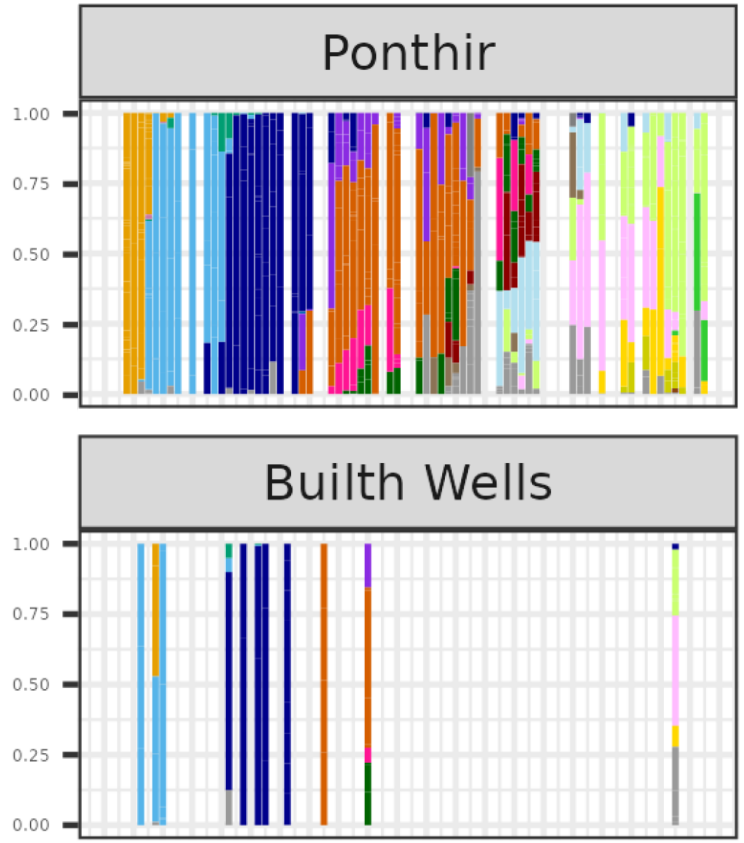
Lessons learnt from Wales

Preparing for pandemic #2

1. Rapid agreement on standard methods (4 nations)
2. More access to QA standards and primers/probes for qPCR
3. Stable supply of consumables and equipment
4. Mixture of skills required
5. Some wastewaters are problematic for sequencing
6. Autosamplers are inherently unreliable
7. Can be barriers to installation of samplers near-source
8. Maintaining a useful bioarchive can be difficult
9. Some reluctance to accept a new way of thinking
10. Not measure things just because we can…
11. Ethical issues need to be considered
12. Near-source pilots are successful, but not scalable/cost-effective/ethical
13. Next pathogen may be infectious in wastewater (BSL-3)

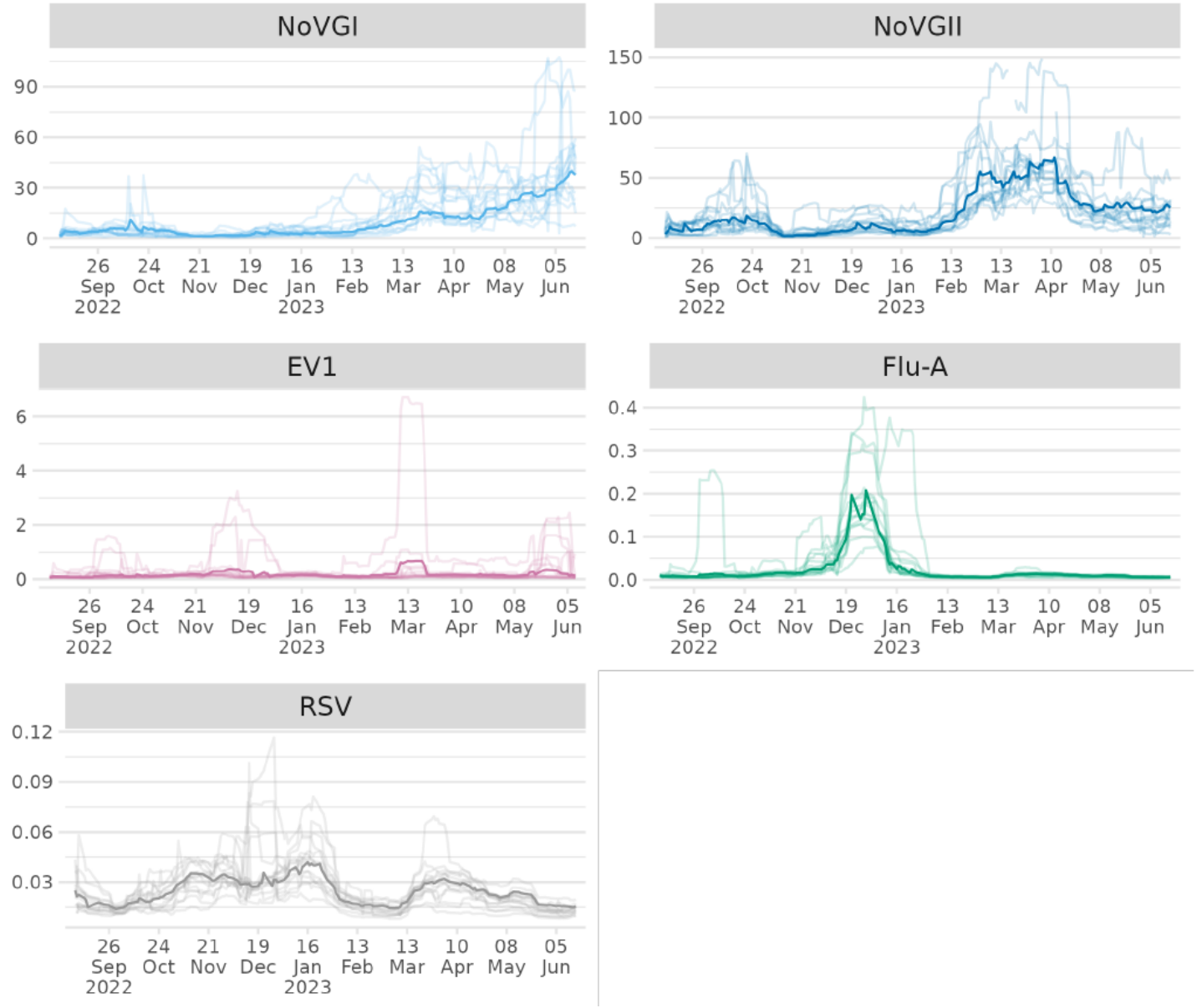
Successes

1. National infrastructure now in place (pandemic prepared)
2. Shown to support national decision making
3. Strong interest in the use of WBE for One Health

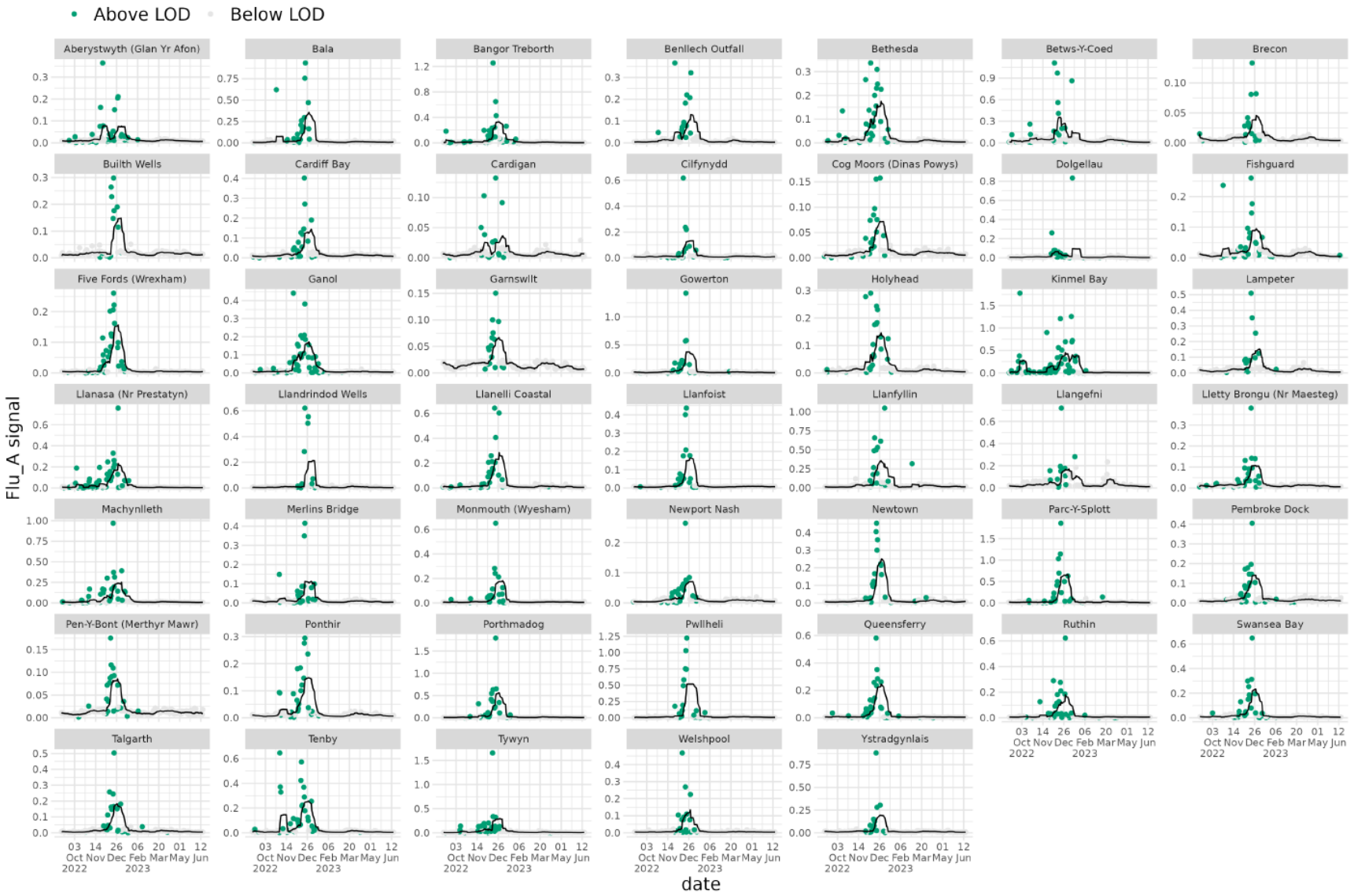


Expanding the public health wastewater portfolio in Wales

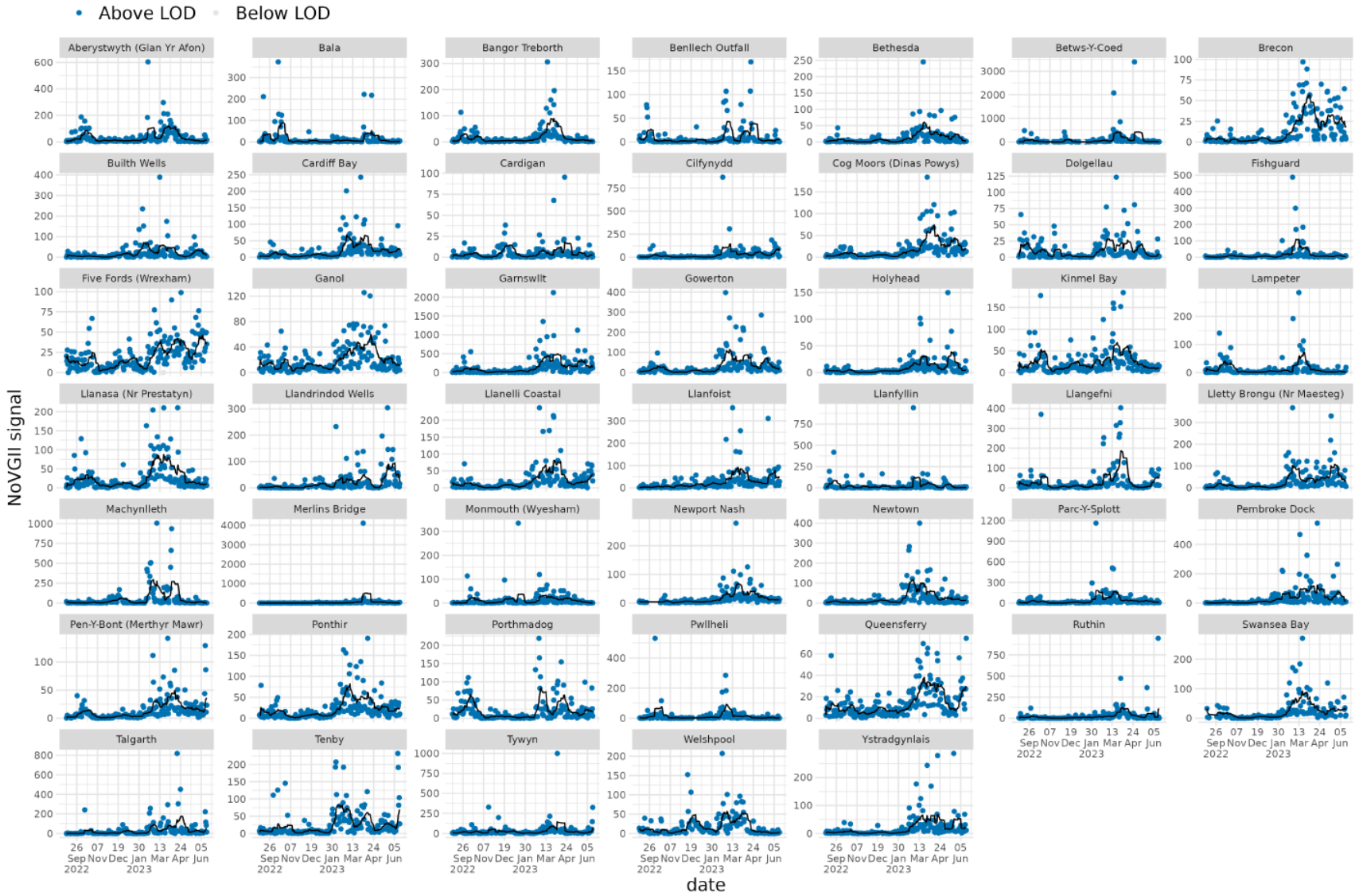
Detection of other viruses in wastewater



Flu A showed a consistent national picture

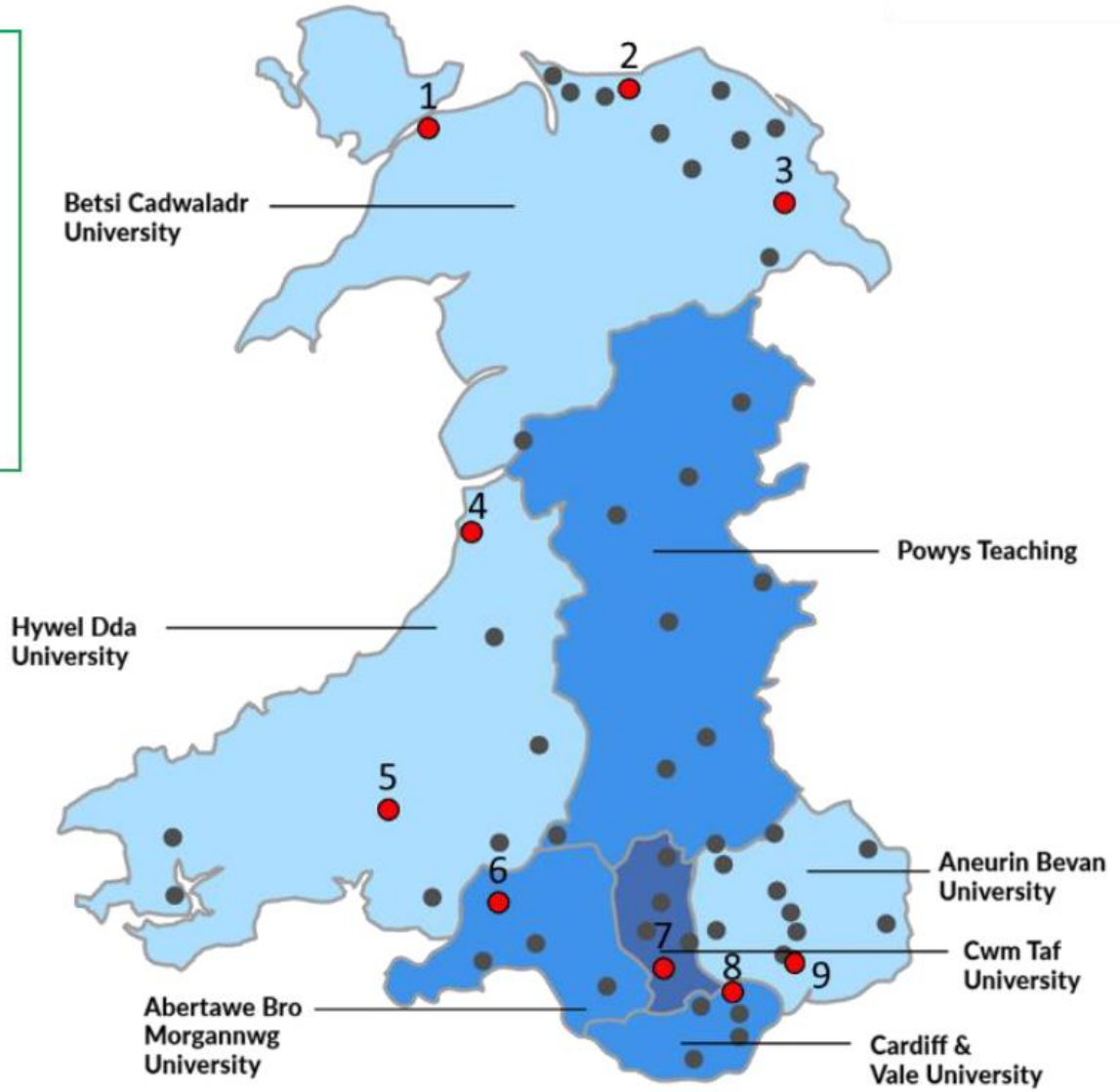


Norovirus showed more localised outbreaks

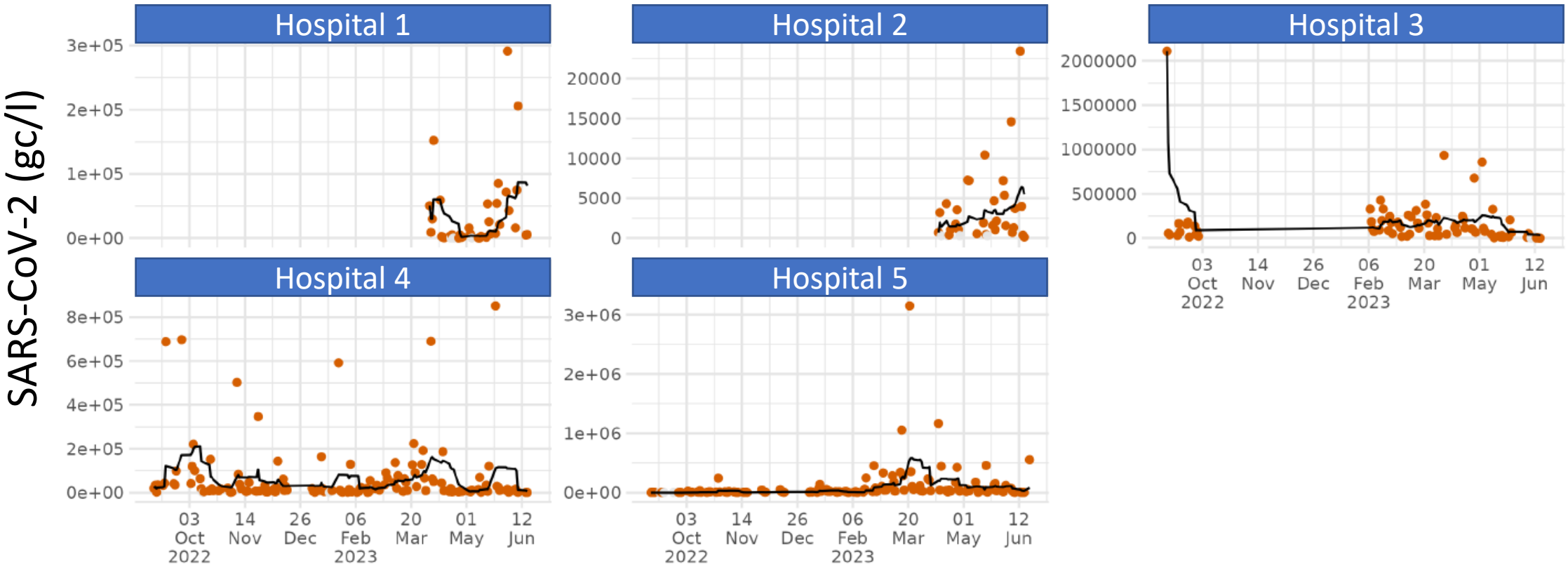


Sampling hospital wastewater in Wales

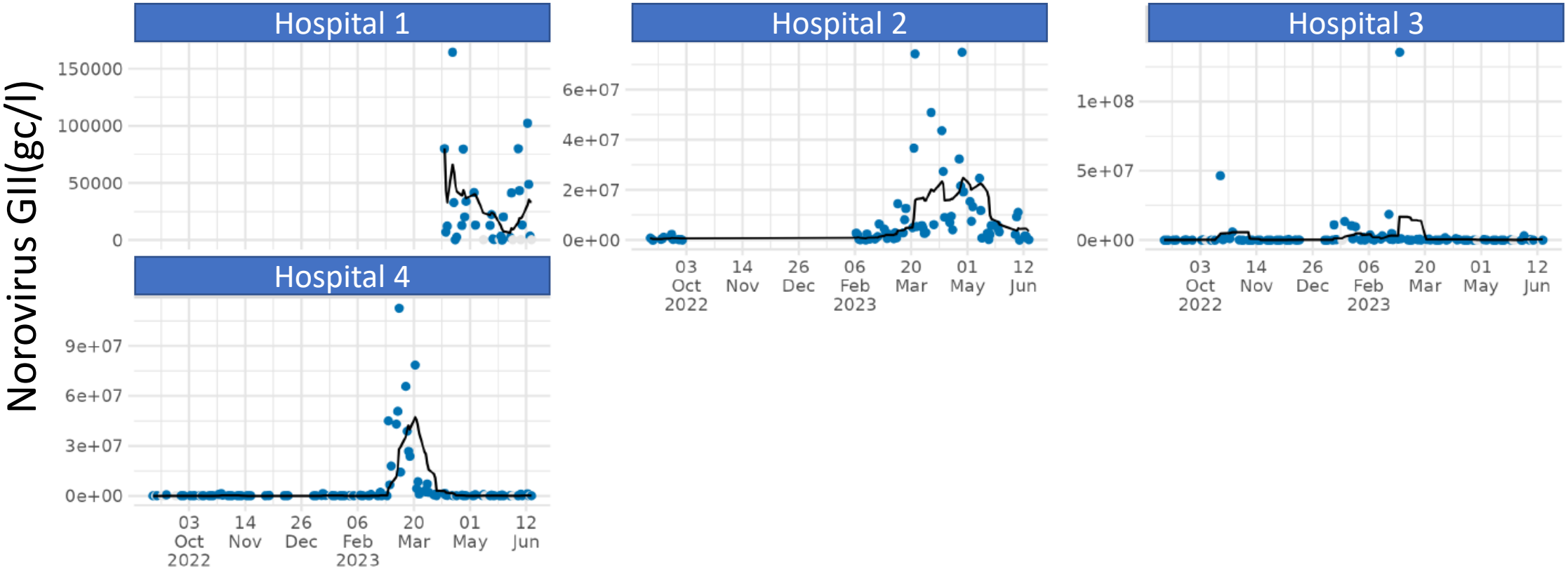
1. Ysbyty Gwynedd
2. Ysbyty Glan Clwyd
3. Wrexham Maelor Hospital
4. Bronglais General Hospital
5. Glangwili General Hospital
6. Morriston Hospital
7. Royal Glamorgan Hospital
8. University Hospital Wales
9. Royal Gwent Hospital



SARS-CoV-2 in Welsh hospital wastewater



Norovirus in Welsh hospital wastewater



Open Access Research

BMJ Open

To close or not to close? Analysis of 4 year's data from national surveillance of norovirus outbreaks in hospitals in England

John P Harris,[1,2] Goutam K Adak,[1,2] Sarah J O'Brien[2]

To cite: Harris JP, Adak GK, O'Brien SJ. To close or not to close? Analysis of 4 year's data from national surveillance of norovirus outbreaks in hospitals in England. *BMJ Open* 2014;**4**:e003919. doi:10.1136/bmjopen-2013-003919

► Prepublication history and additional material for this paper is available online. To

ABSTRACT

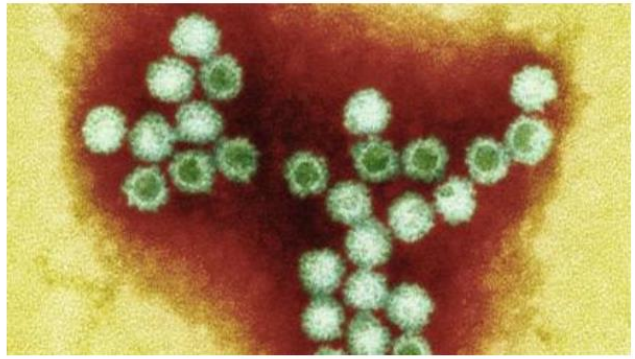
Objective: To assess the impact of ward or bay closures, specifically, whether prompt closure of an affected ward shortens the duration of norovirus outbreaks and the resulting disruption in hospitals.

Design: Analysis of summary data from hospitals on outbreaks of norovirus from 2009 to 2012.

Methods: Using a large outbreak surveillance dataset, we examined the duration of outbreaks, duration of disruption, ward closures, the number of patients and staff affected and the number of lost bed-days, as functions of the timing of closure. We conducted Quasi-Poisson regression analyses to assess the effect

Strengths and limitations of this study

- A large standardised data set for analysis.
- This analysis provides a baseline should infection control strategies move away from whole-ward closures as the new guidelines suggest.
- A weakness is that analysis was carried out on summary data collected on outbreaks from a national web-based reporting scheme, which makes it difficult to unpick some of the questions around the ward characteristics which influence differences in the outcomes.

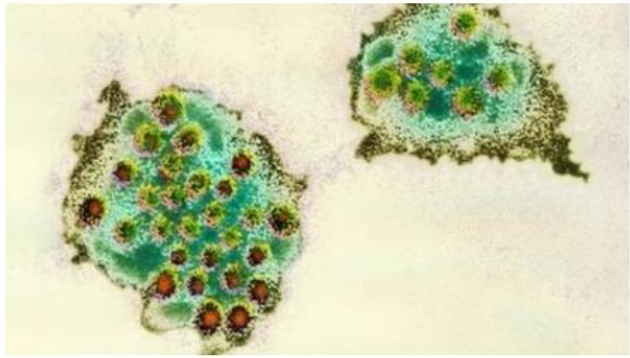


Norovirus vomiting bug hits five north Wales hospitals

The diarrhoea and vomiting bug norovirus spreads to five hospitals across north Wales, with 31 patients falling ill and admission restrictions at eight wards.

University Hospital Wales ward closed by norovirus

The hospital in Cardiff has urged people with symptoms of the illness not to visit the site.



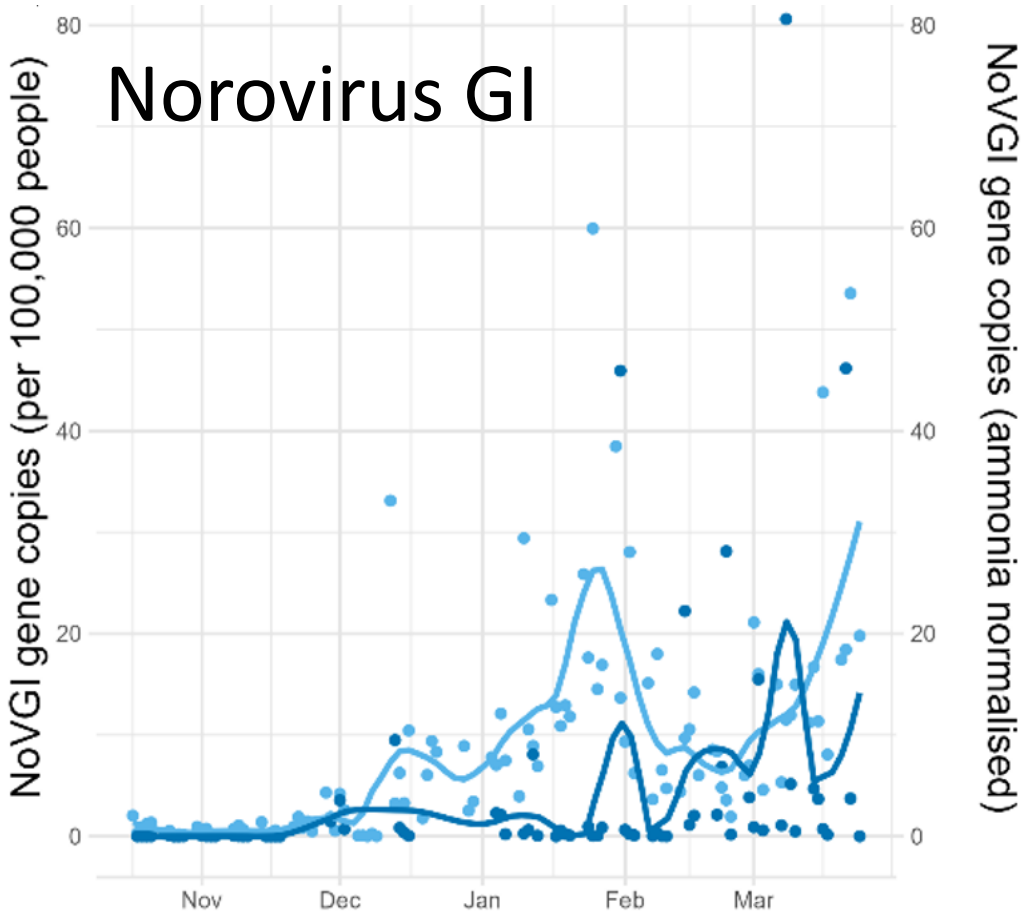
Norovirus: Warning as cases hit three south Wales' hospitals

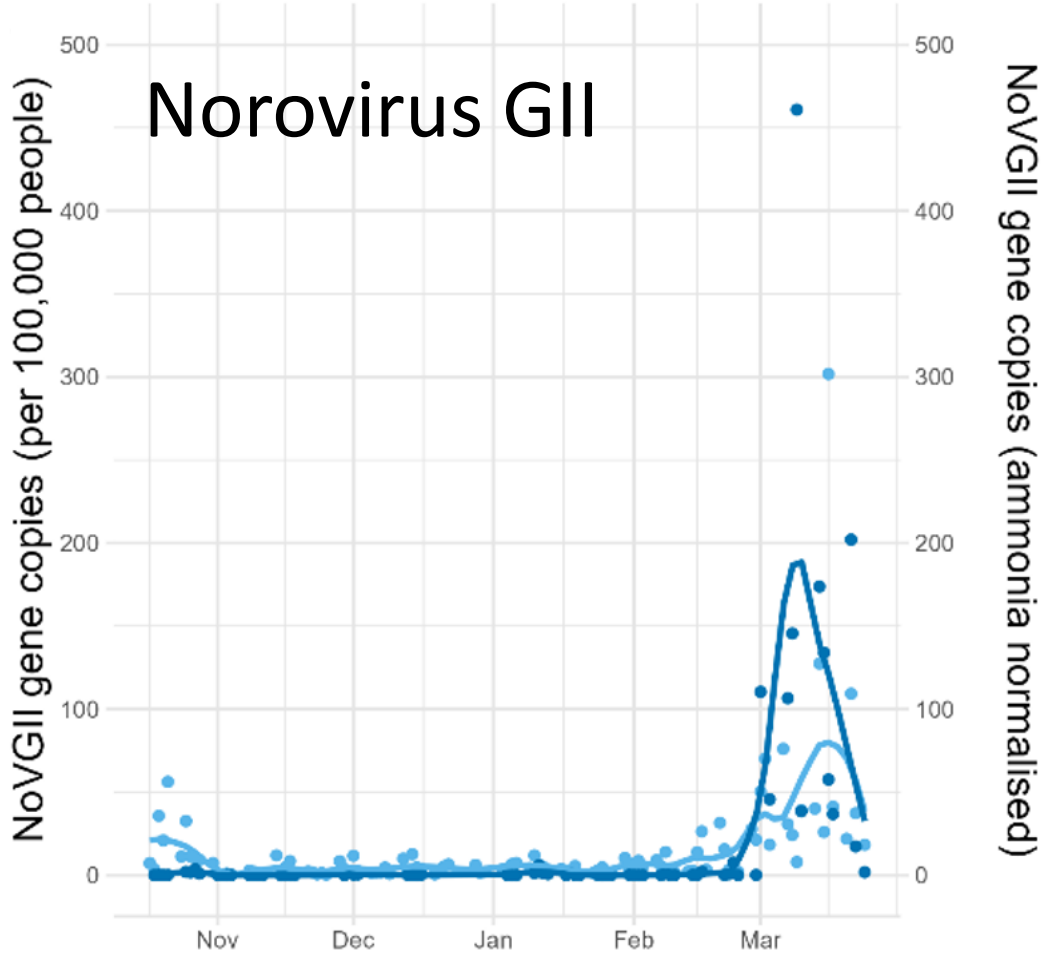
Eight wards are hit by a sickness bug at three hospitals, with managers warning all but urgent cases to stay away.

Does community wastewater provide an early warning system for Norovirus in hospitals?

Community WWTP

Hospital wastewater



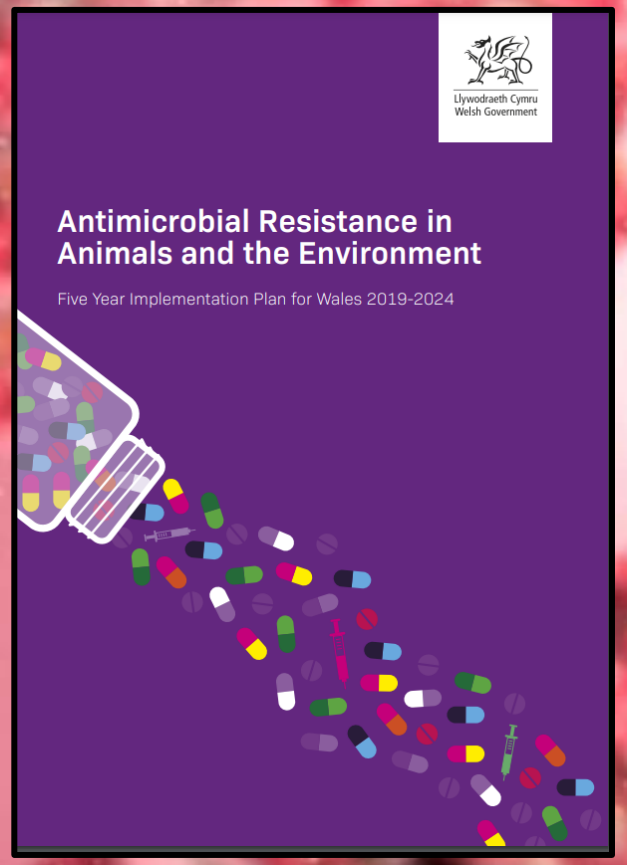


Different infoveillance approaches in Wales

Norovirus syndromic surveillance approach	Data accuracy	Sample size	Regional accuracy	Response time	Relative cost
Self-reporting apps	Low	High	Low	Fast	£
Internet searches	Low	High	Low	Fast	£
School/work absences	Medium	Medium	Medium	Medium	££
Over-the-counter medication sales	High	High	High	Medium	££
Tele-health advice calls	Low	Medium	Medium	Medium	£££
GP surgery visits	Low	Medium	Medium	Slow	££££

Norovirus syndromic surveillance approach	Data accuracy	Sample size	Regional accuracy	Response time	Relative cost
Prescription data	Low	Low	Medium	Slow	££
Urban wastewater surveillance	Medium	High	High	Fast	£££
Hospital wastewater surveillance	High	High	High	Fast	£££
Clinical testing	High	Low	High	Medium	£££££
'Event-based' testing of outbreaks/incidents	High	Low	High	Fast	££££
Emergency hospital admissons	High	Low	High	Fast	£££

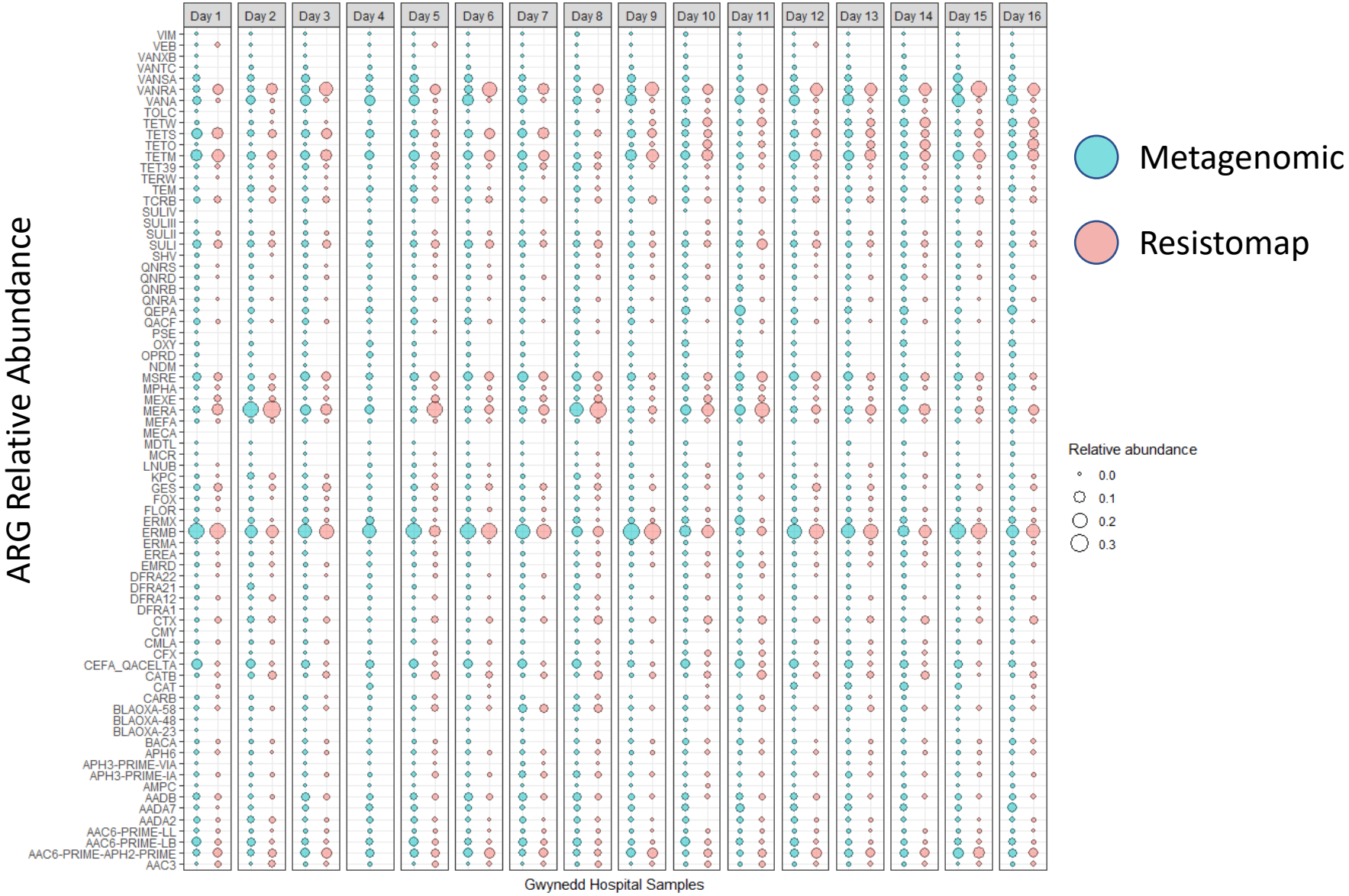
Key priority: We need to better integrate these data streams



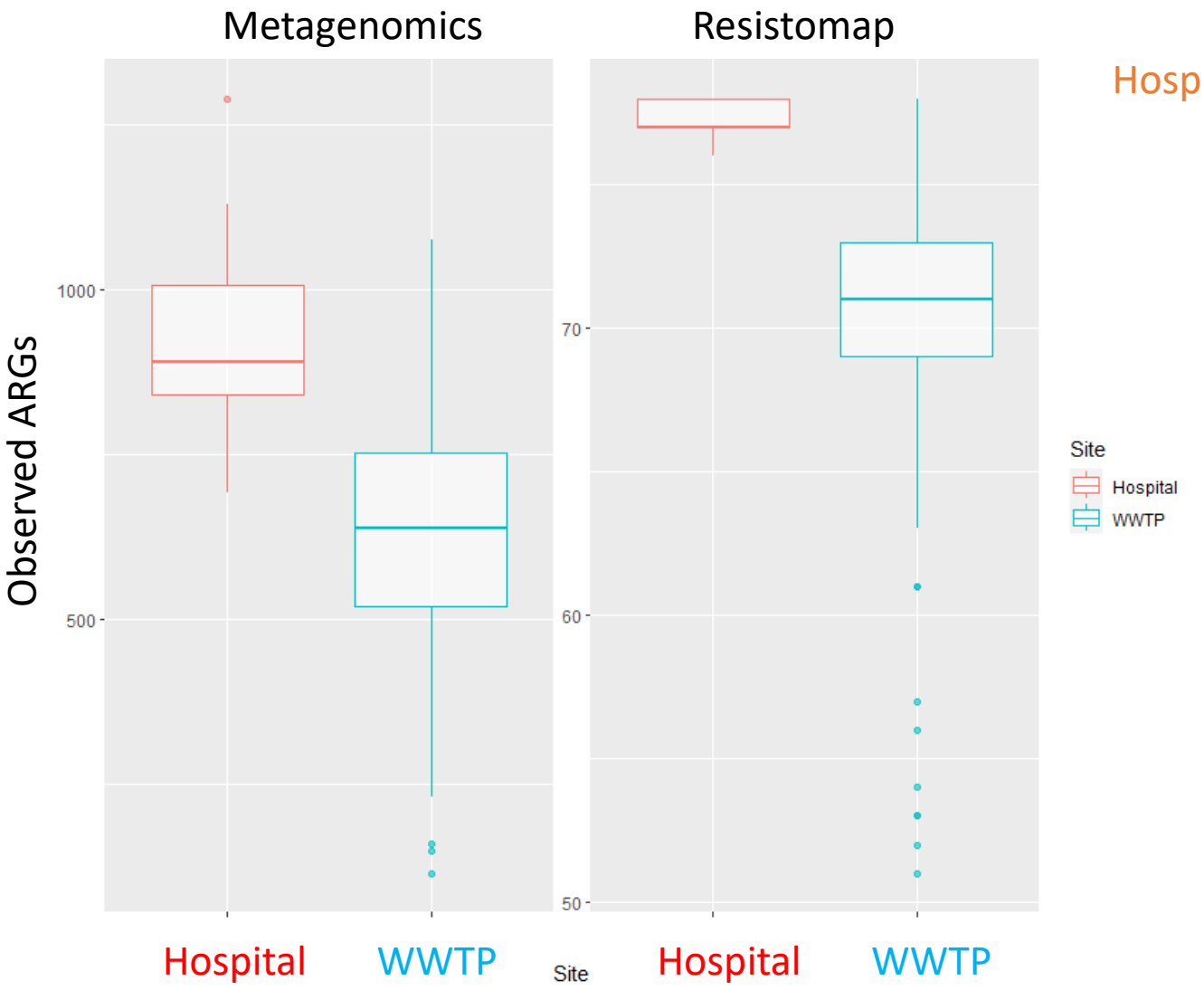
Expanding into anti-microbial resistance to support Welsh policy

Can wastewater fill a gap in AMR monitoring within Wales?

HT-qPCR vs. metagenomic approaches for AMR



HT-qPCR vs. metagenomic approaches for AMR



Hospital wastewater is a hotspot for AMR release

HT-qPCR

- Easier to perform
- Data reporting slower for decision-making
- Limited number of gene targets
- No hosts identified
- Data insights

Metagenomic approaches

- More labour intensive
- More bioinformatics
- High performance computing
- Data-rich for endless mining
- MAG analysis to identify organisms carrying ARGs
- Faster data reporting?

Culturing approaches

- Environmental release

Can AMR surveillance in wastewater help infection control in hospitals?

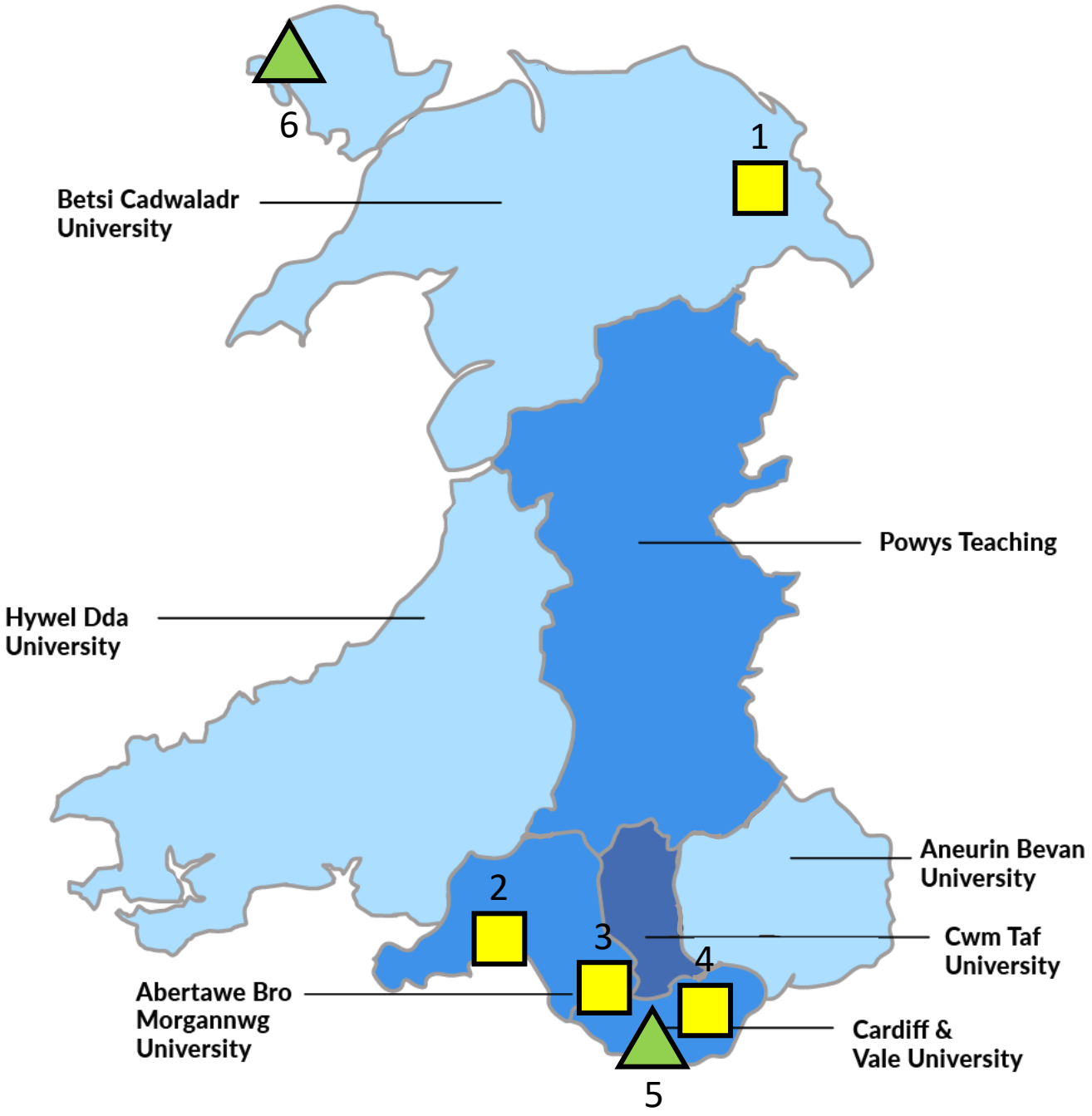
- Increased knowledge of the types/evolution of organisms involved
- Improved understanding of AMR movement between hospitals
- Linking hospital infections to those in the local community
- Estimate entry/exit rates of ARGs into hospitals
- Early warning system (if data produced in a timely way)
- Still need to work with clinical infection teams to best use the data
- Link to national and international databases
- Environmental exposure from wastewater (One Health)

Prison sampling sites

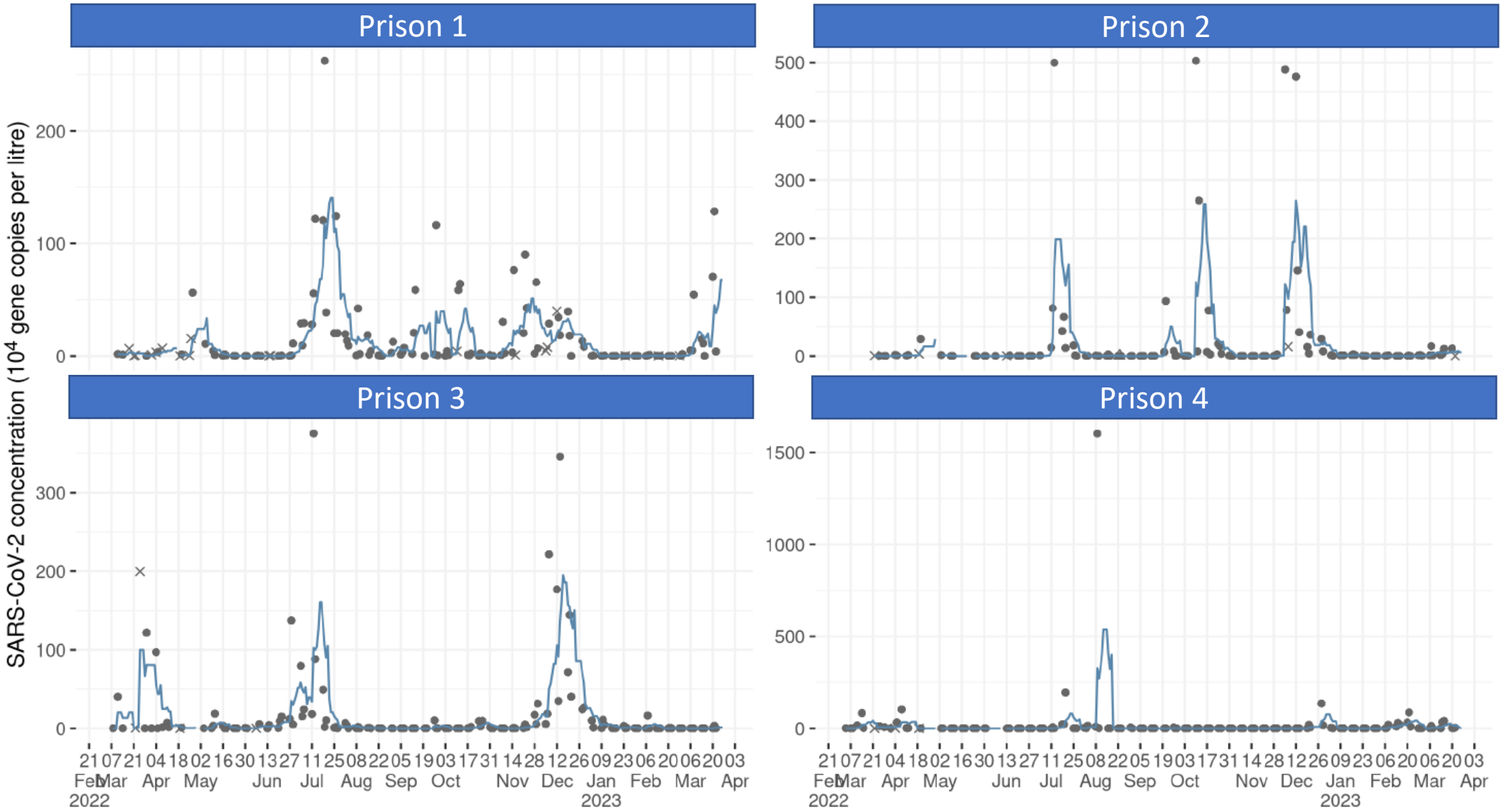
1. HMP Berywn
2. HMP Swansea
3. HMP Parc (Bridgend)
4. HMP Cardiff

International border sites

5. Cardiff Airport
6. Holyhead ferryport

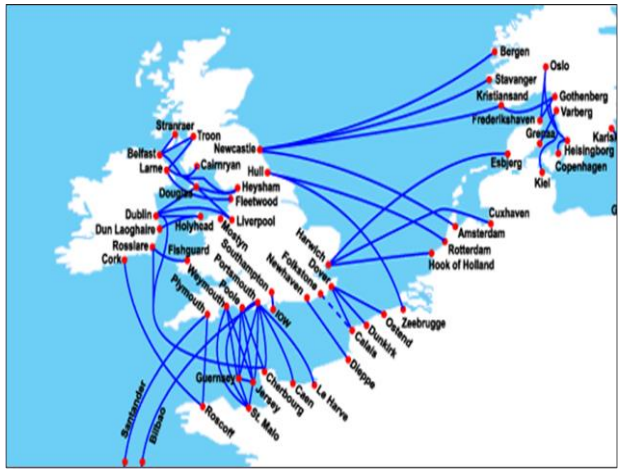


COVID-19 monitoring in Welsh prisons

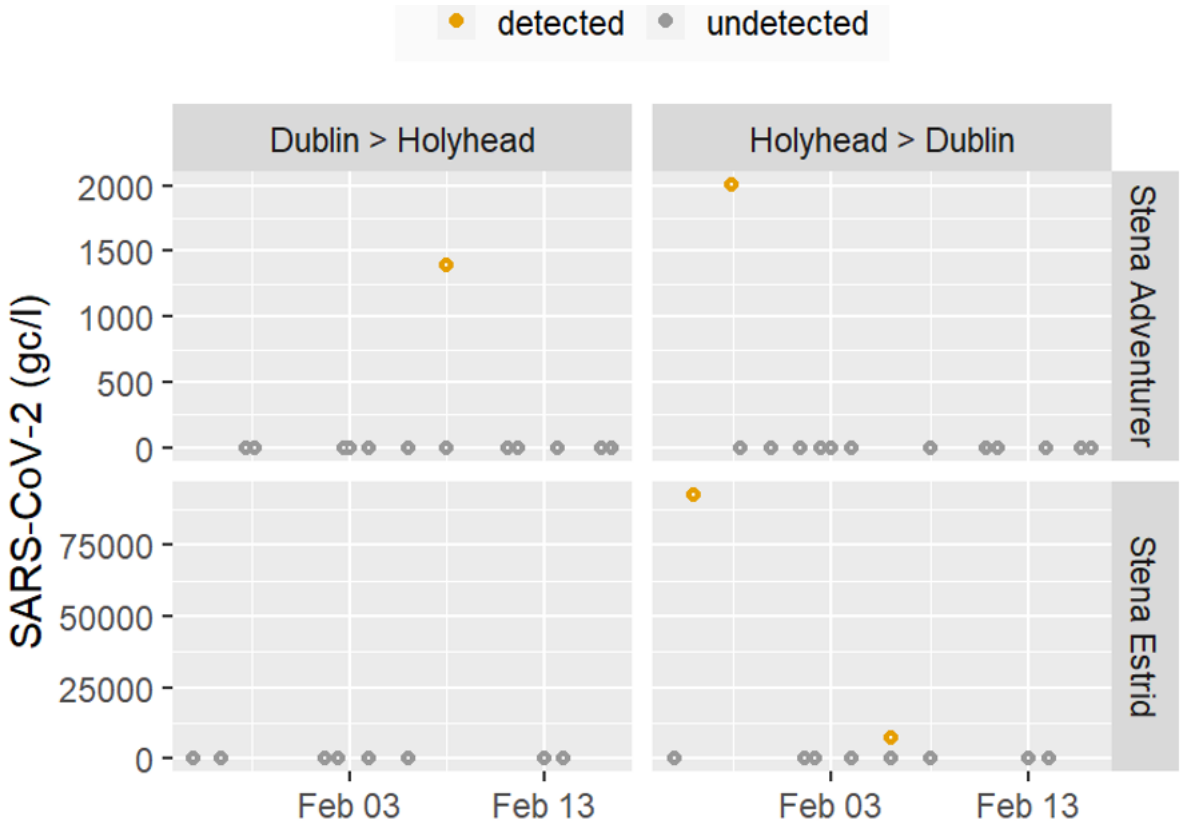


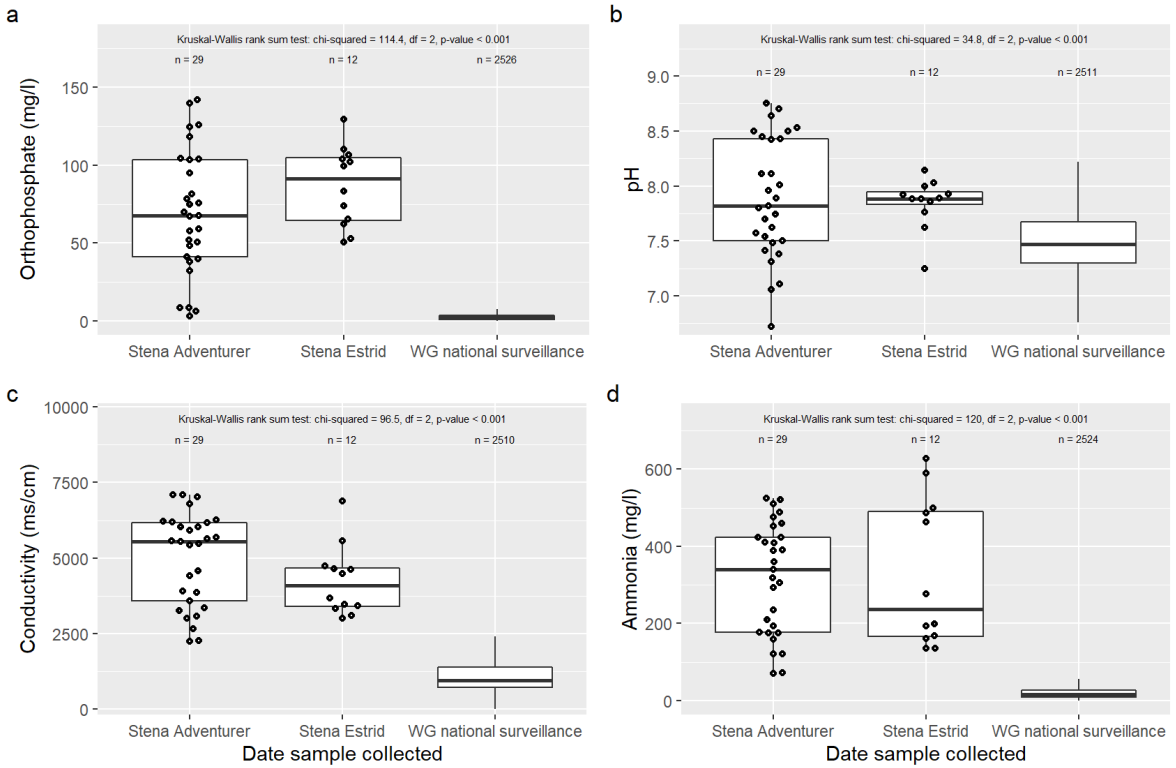
How did this influence decision making
……..and how can we learn from this?

Tracking the international entry rate of COVID-19 from Ireland-Wales



Detection of SARS-CoV-2 in wastewater from ferries





A small proportion of the wastewater samples were positive for SARS-CoV-2 (8% of the total)
This was consistent with theoretical predictions of detection frequency (4-15% of the total)

Conclusions

- National WBE programme in Wales has been successfully running and reporting for >2 years.
- Long-term success down to being co-developed with Welsh Government and Dŵr Cymru.
- Wastewater SARS-CoV-2 variant and abundance data has impacted on policy decisions regarding COVID-19 (building confidence in WBE).
- Expanded to include a wide range of other targets (e.g. Norovirus, AMR) where current surveillance approaches are poor.
- Profile and confidence of WBE as an intelligence source has increased since the reduction in mass testing and changes in population behaviour.
- Still work to be done to build confidence with health protection policy leads and public health professionals (social science & behaviour change).
- Still need to combine with clinical data and other infoveillance data when reporting.
- Now a strong move to looking downstream in a *One Health* context, especially now we have the national infrastructure (influent and effluent). Pandemic sleeping capacity.


Moving towards a One Health agenda

Taxonomy profile for Comparison_allreads_allsamples_viral2018_absolute.megan (rank=Family)

sapo/norovirus

rotavirus

Family level groupings

Alloherpesviridae
Alphaflexiviridae
Alphatetraviridae
Ascoviridae
Asfarviridae
Baculoviridae
Betaflexiviridae
Caliciviridae
Chaetoceros tenuissimus RNA virus type-II
Circoviridae
Dicistroviridae
Endornaviridae
environmental samples <Picornavirales>
environmental samples <ssRNA positive-strand viruses, no DNA stage>
Fisavirus 1
Flaviviridae
Genomoviridae
Herpesviridae
Hypoviridae
Iflaviridae
Inoviridae
Iridoviridae
Lavidaviridae
Leviviridae
Luteoviridae
Marseilleviridae
Microviridae
Mimiviridae
Myoviridae
Nanoviridae
Namaviridae
Nodaviridae
Nudiviridae
Partitiviridae
Parvoviridae
Phycodnaviridae
Picobirnaviridae
Picornaviridae
Podoviridae
Poxviridae
Reoviridae
Secoviridae
Sinaivirus
Siphoviridae
Sobemovirus
Tectiviridae
Tombusviridae
Totiviridae
Tymoviridae
unassigned Picornavirales
unclassified bacterial viruses
unclassified Caudovirales
unclassified dsDNA phages
unclassified dsDNA viruses
unclassified Picornavirales
unclassified RNA viruses
unclassified ssDNA viruses
unclassified ssRNA negative-strand viruses
unclassified ssRNA positive-strand viruses
unclassified virophages
unclassified viruses
Virgaviridae
Virtovirus

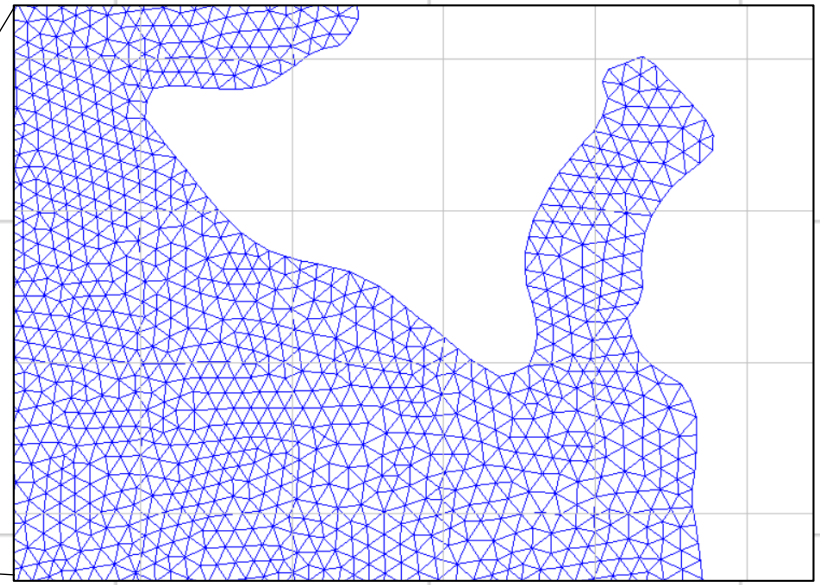
wastewater

mussels

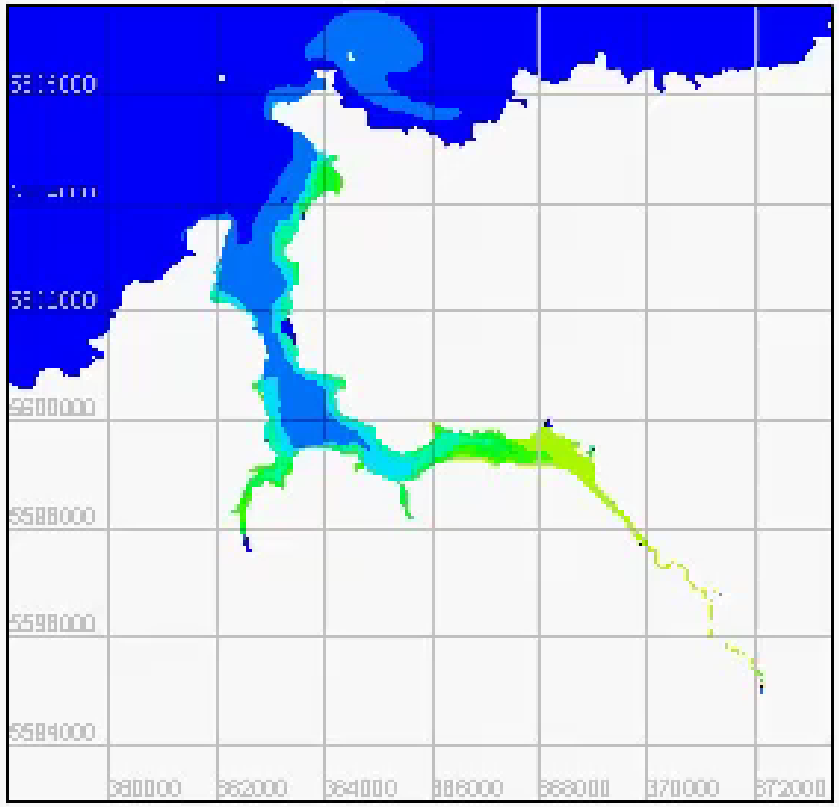
river/est. water

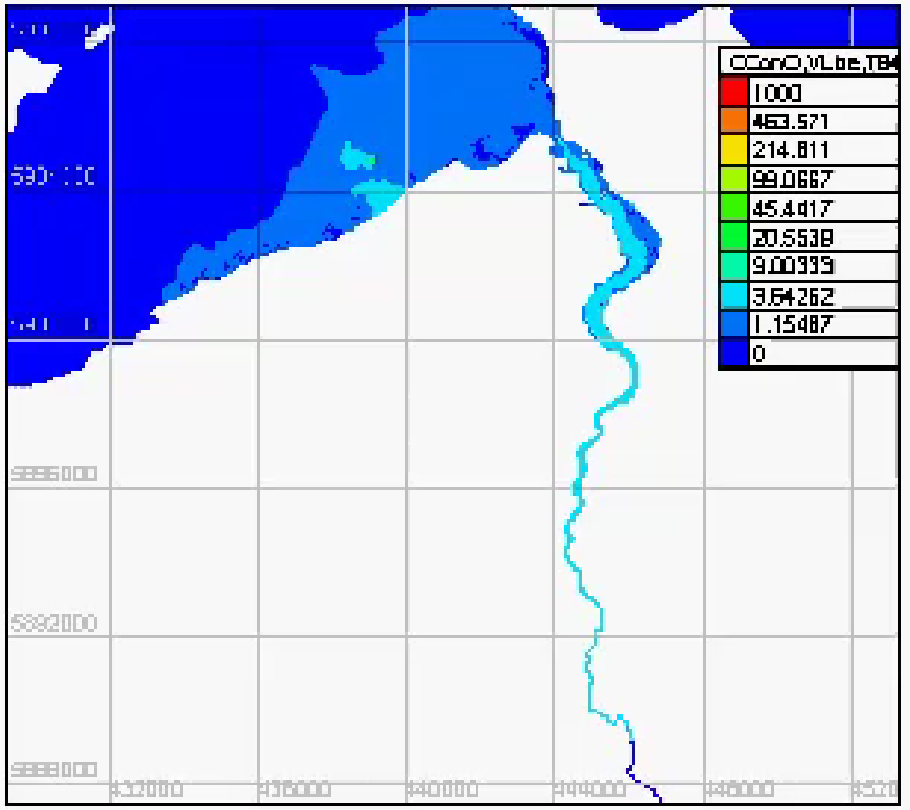
sediment

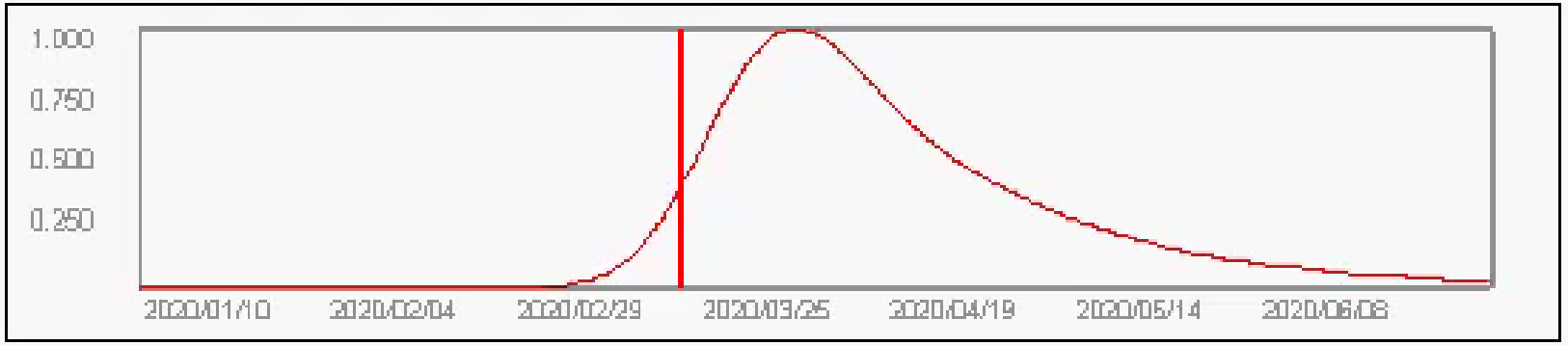
Telemac-2D Hydrodynamics Model



- **Unstructured-mesh bathymetric grid.**
- **Solves depth averaged shallow water Saint-Venant equations of momentum and continuity at each time step (1s)**
- **Models validated against salinity .**







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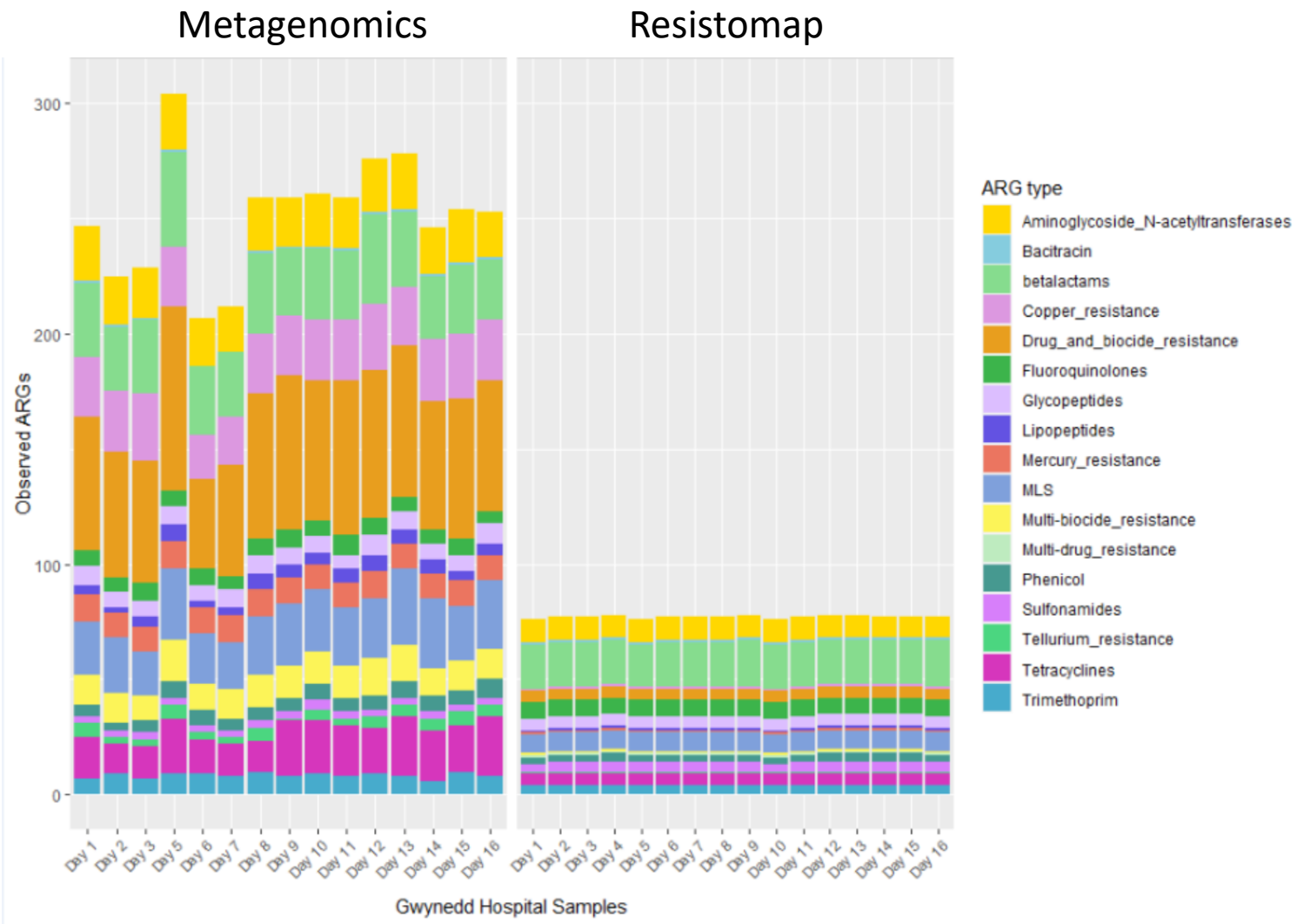
HT-qPCR vs. metagenomic approaches for AMR



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