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Food Standards Agency

- Independent government department
- No minister – links to parliament through health ministers
- Set up in 2000 and makes use of mathematics across the remit
- Covering in this presentation
  - Radiological protection
  - Campylobacter
  - Norovirus modelling
  - Plans for big data analytics

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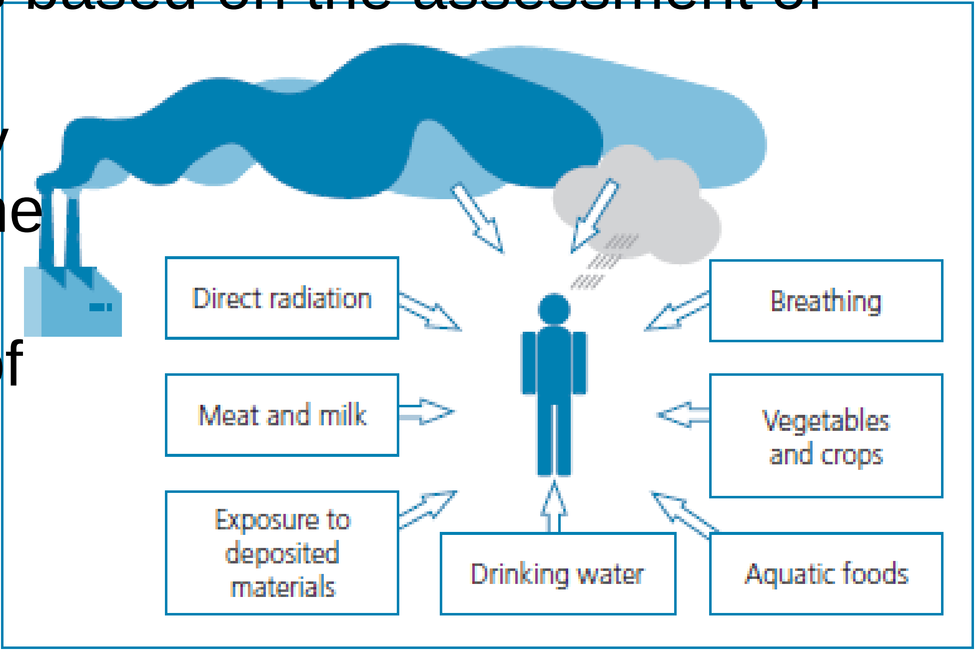
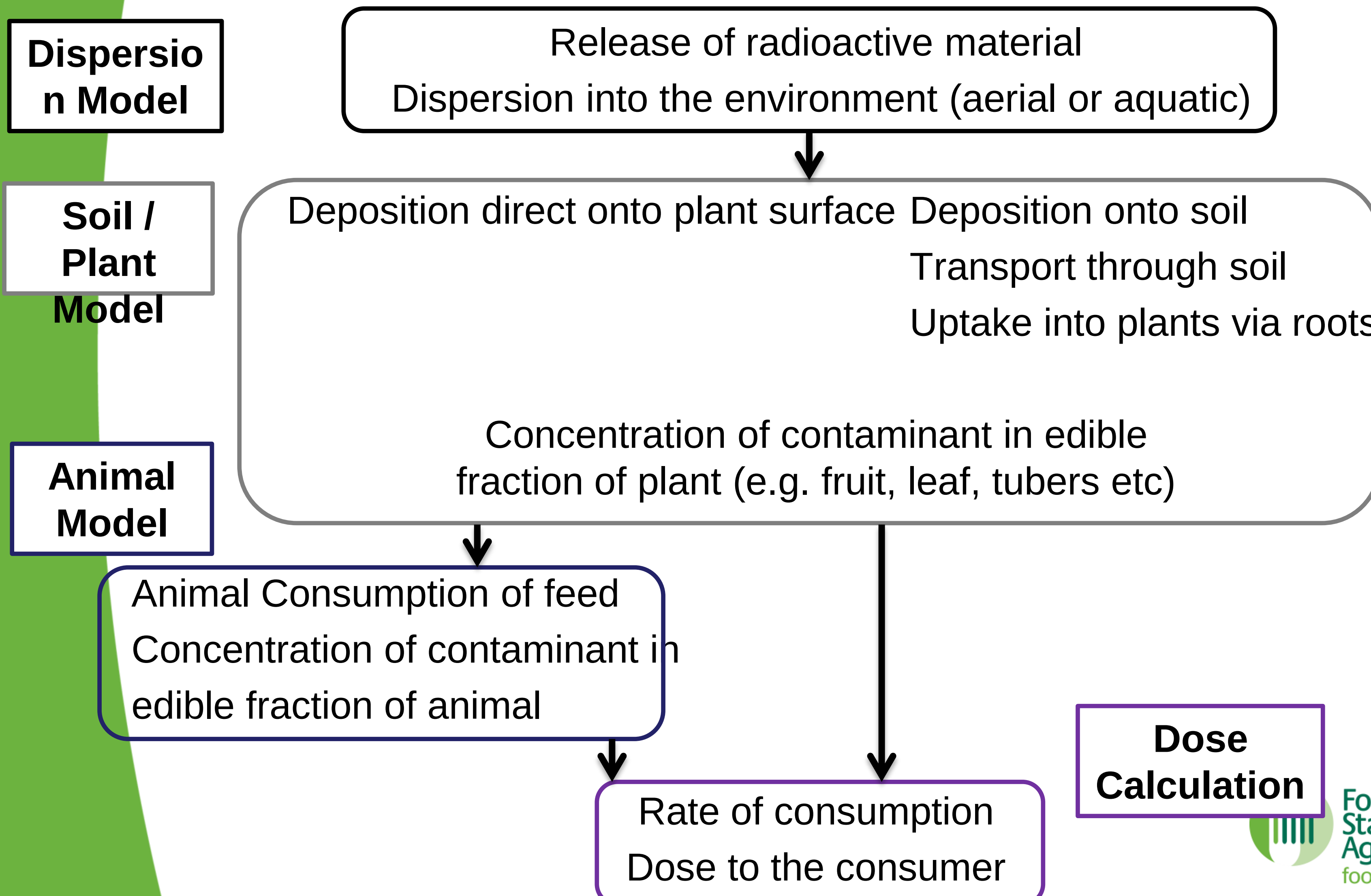
Assessing the impacts of radiological releases into the environment

- When a nuclear facility releases radioactive material into the environment (as part of routine operations or an accidental release), it has the potential to contaminate food.
- Radiological protection is based on the assessment of dose from all pathways.
- The Environment Agency will consult the FSA on the proposed emissions.
- The FSA has a number of models to assess the impact on food safety.



Mathematical models used



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Atmospheric Dispersion

$$C_{x,y,z} = \frac{Q_s}{2\pi\sigma_y\sigma_z U} e^{\frac{y^2}{2\sigma_y^2}} \left(e^{-\frac{(z-z_s)^2}{2\sigma_z^2}} + e^{-\frac{(z+z_s)^2}{2\sigma_z^2}} + e^{-\frac{(z+2h-z_s)^2}{2\sigma_z^2}} + e^{-\frac{(z-2h+z_s)^2}{2\sigma_z^2}} + e^{-\frac{(z-2h-z_s)^2}{2\sigma_z^2}} \right)$$

$C_{x,y,z}$ = concentration of contaminant at co-ordinate x,y,z

Q_s = source strength (per unit time)

z_s = height of the source

σ_y = transverse dispersion parameter

σ_z = vertical dispersion parameter

} function of travel time, buoyancy and turbulence

U = wind speed

h = atmospheric boundary layer height (varies depending on season, diurnal cycle, weather conditions and physical geography)

Uptake of contaminant by plants

$$U = 2\pi\, a\, \Delta z\, \rho_r \frac{F_m C_{solution}}{R_m + C_{solution}}$$

U = plant uptake (mole m^{-2} y^{-1})

a = root radius (m)

Δz = soil layer thickness (m)

ρ_r = total plant-root length per unit volume (m)

F_m = maximum specific flux across the root surface (mole m^{-2} y^{-1})

$C_{solution}$ = contaminant concentration in solution (mole m^{-3})

R_m = calibration constant equal to the concentration in the soil solution at which the specific flux across the root surface is half its maximum value (mole m^{-3}) – determined by experiment

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Calculate dose to consumer

$$D = M\ A_{concentration}\ e_{ingestion}$$

D = Dose to consumer in sieverts (Sv)

M = Quantity of food consumed (kg) – determined by habit surveys

$A_{concentration}$ = Activity concentration in food in becquerels per kilogram (Bq / kg)

$e_{ingestion}$ = Dose coefficient for ingestion (Sv / Bq) which is dependent on the radionuclide of interest and age group of consumer

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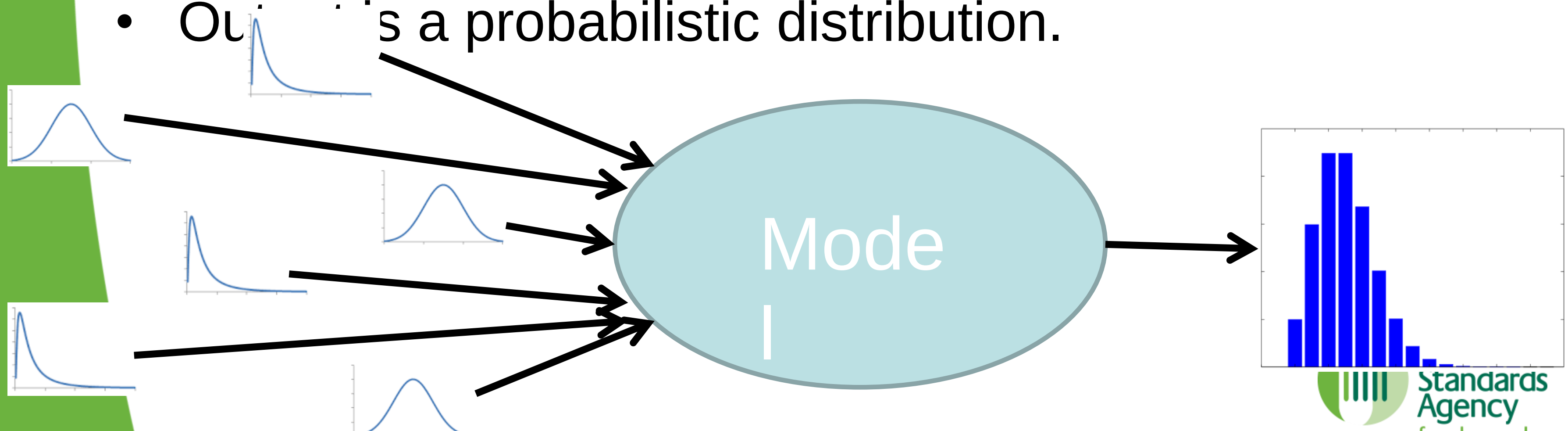
Probabilistic Modelling

- These models have been developed over a period of 30 years.
- Continually looking for improvements – most recent development is probabilistic modelling.
- Various input parameters can be given as normal or log-normal distributions.
- Output is a probabilistic distribution.



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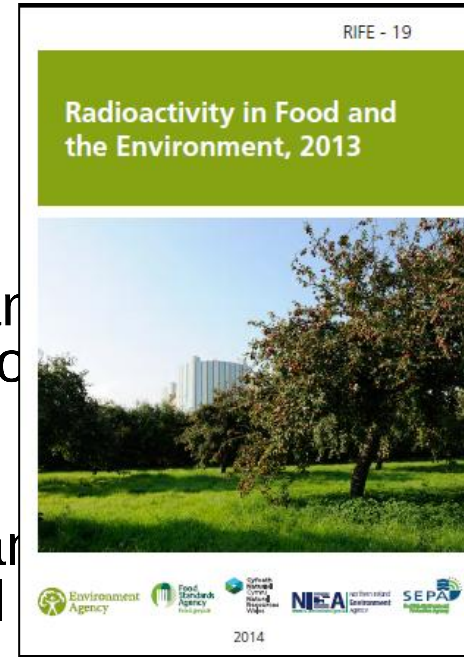
Verification with monitoring



- The FSA regularly monitors food produced around nuclear facilities in the UK.
- Data from the FSA is combined with the environment agencies (EA, SEPA, NIEA) ar published annually in the Radioactivity in Fo and Environment Report.
- These results confirm that the levels of contamination in the environment are low ar the doses to consumers are far below legal limits.

- More details can be found on the FSA website:

http://www.food.gov.uk/science/research/radiologicalresearch/radiosurv/

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Campylobacter and chicken

- *Campylobacter* is the most common cause of food poisoning in the UK accounting for an estimated 280,000 cases each year.
- Work undertaken by the FSA in-house analytical team found that poultry was the main source of *Campylobacter* from food.
  - Based on outbreak data compiled by the UK's surveillance bodies;
  - Multilocus sequence typing (MLST) comparing human isolates to those from the environment, wildlife and farm animals.
    - Handling, preparation and consumption of broiler meat may account for 20% to 30% of human cases of campylobacteriosis, while 50% to 80% may be attributed to the chicken reservoir as a whole.
- In addition a 2008 EFSA survey found 75% of UK batches were contaminated, with 27% of carcases being in the higher, and more risky, contamination bands at the end of slaughter.

Food source	*Campylobacter* outbreaks over three calendar years (2011-13)
Poultry	85%
Red Meat	5%
Milk & dairy	5%
Dessert	5%
Eggs	0%
Fruit & Veg	0%
Fish	0%
Shell-fish	0%
Rice	0%

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Target level of reduction

- A target has been agreed jointly between government and industry to reduce *Campylobacter* in UK produced chicken.
  - Based on mathematical modelling undertaken internally by the FSA.
- The target is monitored through sampling using a banding approach, according to *Campylobacter* counts in chicken.
  - <100 cfu/g, 100-1,000 cfu/g, and >1,000 cfu/g.
- The target focuses on decreasing the proportion of birds in the most contaminated group.

- **THE TARGET: Reduce the percentage of highly contaminated chickens in UK poultry slaughterhouses from 27% to 10%.**

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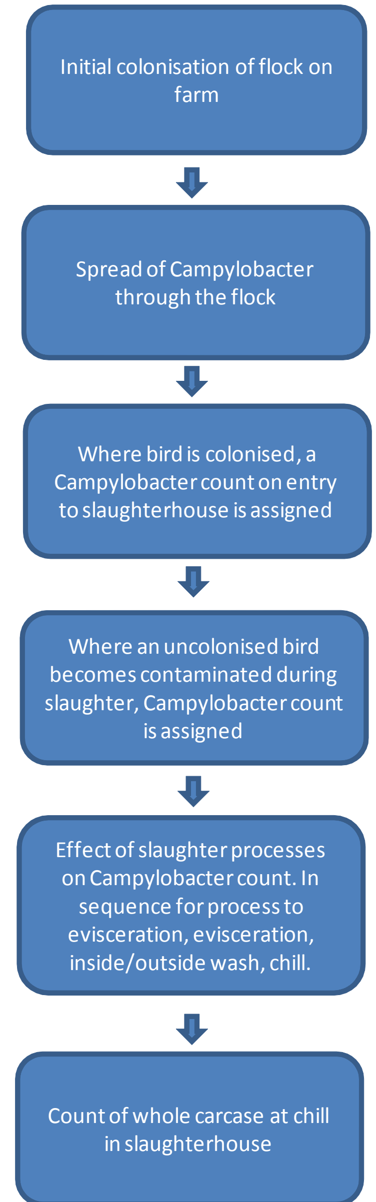
The model

- <u>Monte Carlo simulation</u> model constructed to simulate the effects of the chicken production process on an average bird from growing on farm and through the slaughterhouse.
  - Based on the CODEX web-based tool.
- Data on the effects of standard production processes and potential interventions on *Campylobacter* counts were incorporated into the model.
  - Sourced from a combination of available research, monitoring and surveys, and from the expert opinion of members of the group.
  - Assumptions were made where data was limited.
- A range of interventions were evaluated to give indications of the potential size of reductions.
- Results of the model were used to frame discussions as to what might be an achievable, realistic and challenging target.



Flow diagram to represent the chicken production process

Model results

Scenarios modelled

	Intervention	*Campylobacter* counts (cfu/g; post chill)		
		<100	100 - 1,000	>1,000
One intervention	Model Baseline	39%	33%	**28%**
	On farm - risk of contamination reduced by 50% per day	56%	24%	**20%**
	On farm - risk of contamination reduced by 25% per day	45%	30%	**25%**
	Slaughterhouse - electrolysed water	81%	16%	**3%**
	Slaughterhouse - lactic acid	78%	18%	**4%**
	Slaughterhouse - hot water	67%	23%	**10%**
	Slaughterhouse - Steam	71%	19%	**10%**
Two interventions	On farm + electrolysed water	86%	12%	**2%**
	On farm + lactic acid	84%	13%	**3%**
	On farm + hot water	66%	27%	**7%**
	On farm + steam	79%	14%	**7%**

Final scenario agreed and used to set target

	Intervention	*Campylobacter* counts (cfu/g; post chill)		
		<100	100 - 1,000	>1,000
	On farm + representative slaughterhouse intervention	68%	22%	**10%**

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TWITTER – NOROVIRUS MODEL

How it Works

1. Early-warning tool on Norovirus spikes – helps decide when to intervene
2. Set of words relating to Norovirus symptoms generated
3. Weekly use volumes of words collected using social media listening software
4. Fortnightly changes in word use/lab reports calculated
5. Word use volumes lagged by four weeks to allow model to be predictive
6. Correlations between lagged word use volumes and lab reports calculated
7. Words with significant correlation used in logistic regression model
8. Logistic model predicts if there will be a significant rise or not in next fortnight

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TWITTER – NOROVIRUS MODEL

The Maths

1. FACTOR ANALYSIS: Used to group approximately 70 different keywords into 10 groups of similarly correlated words (often with similar subject too)

2. BIVARIATE LOGISTIC REGRESSION: Uses changes in keyword groups to predict whether or not there is to be a significant change

3. RECEIVER OPERATOR CHARACTERISTIC CURVE: Uses variation of true/false positives/negatives depending on cut off threshold in log. regression model to decide on most accurate model:
   - Initial model had a cut off of 0.5 – approx. 45% accurate
   - Revised model had a cut off of 0.35 – approx. 70% accurate

4. PROPOSED NEW TECHNIQUES:
   - MULTIVARIATE LOGISTIC REGRESSION: Will predict size of change on predefined scale
   - MACHINE LEARNING: More accurate method of identifying at what point a ‘significant change’ is occurring

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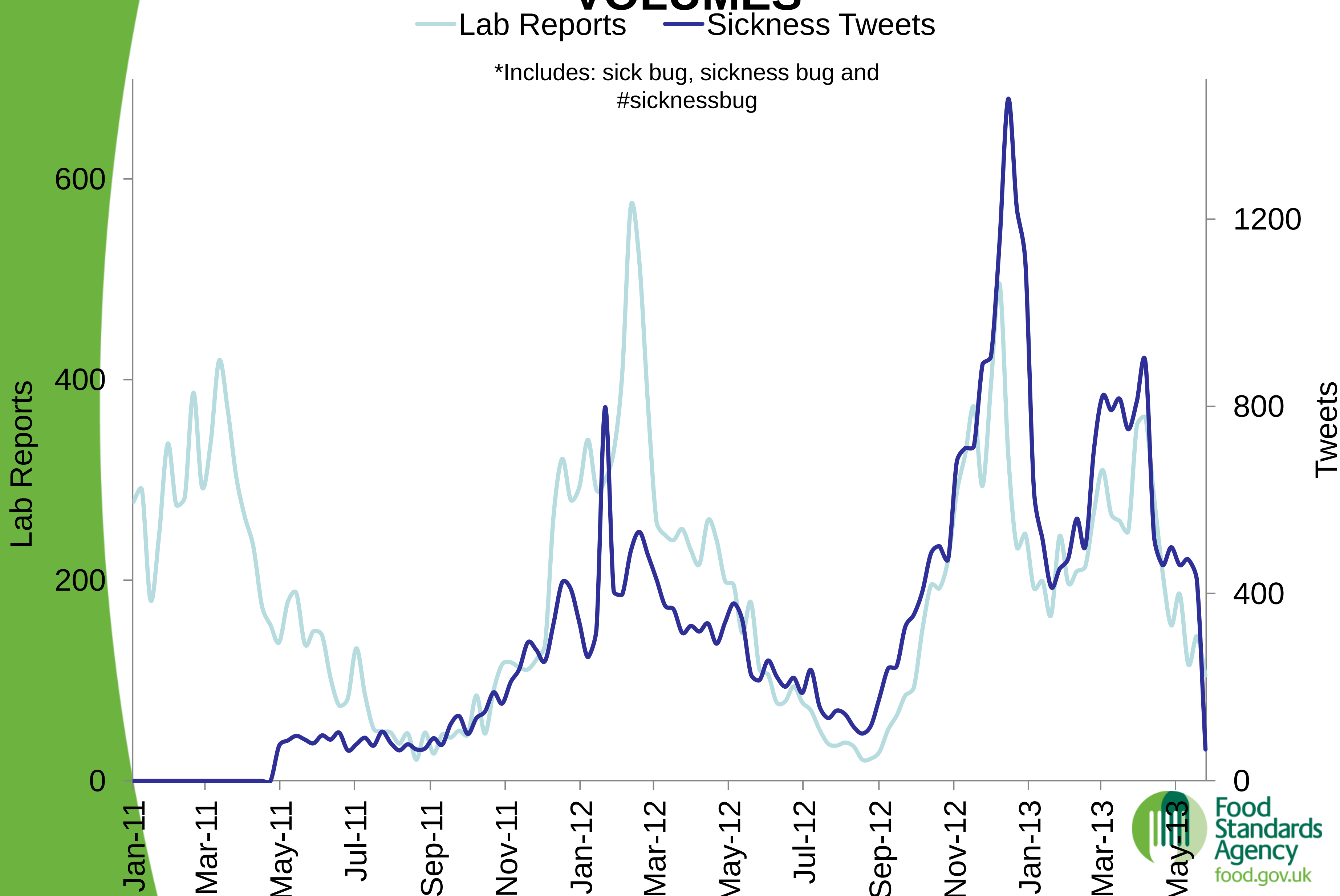
LAB REPORTS vs. TWEET VOLUMES



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White Rose Projects

- FSA are part of an ESRC White Rose Network on the topic of food safety and big data
- This network will be a collaboration between the universities of Leeds, Sheffield and York, with the FSA and Pulsar as external partners.
  - Pulsar is a private sector social media platform
- The network will provide three three-year PhD studentships across a number of disciplines with the aim of harnessing the power of big data to produce new insights into food safety.

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Project 1: Using Visual Social Media Data to Better Understand Food Safety Cultures

- A vast amount of social media image data is posted online every day
- The aim is to explore how these images can be used to understand food behaviours
- The project will investigate whether image data can be used to quantify behavioural change.
- Patterns in the sharing of images on social media will also be explored

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Project 2: Spatial Data Analytics for Food Safety

- Existing approaches have yet to exploit fully the power of spatial analysis in the consumption of food
- The introduction of more sophisticated representations of restaurant catchments and the interaction patterns of their customers could allow more subtle and powerful representations of risk profiles.
- This could provide a valuable means to prioritise scarce resources for health inspection, and could provide a means for rapid and early detection of problems in a specific location or neighbourhood.

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Project 3: Food Fraud and Big Social Data

- Understanding consumers' opinions and behaviours is a key element of putting consumers at the heart of the FSA's work.
- Existing literature investigates consumer behaviour by survey-based and/or focus group approaches, in which the generality of outcomes may depend on the robustness of the sampling approach
- Research has shown that Twitter post monitoring is an effective tool to track the public response to a particular event. This project will explore the potential for such data to generate insights into the public reaction to adulteration and contamination events.

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