Greater Manchester
Primary Care Patient Safety
Translational Research Centre

Development and preliminary validation of a dynamic, patient-tailored method to detect abnormal laboratory test results

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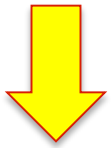
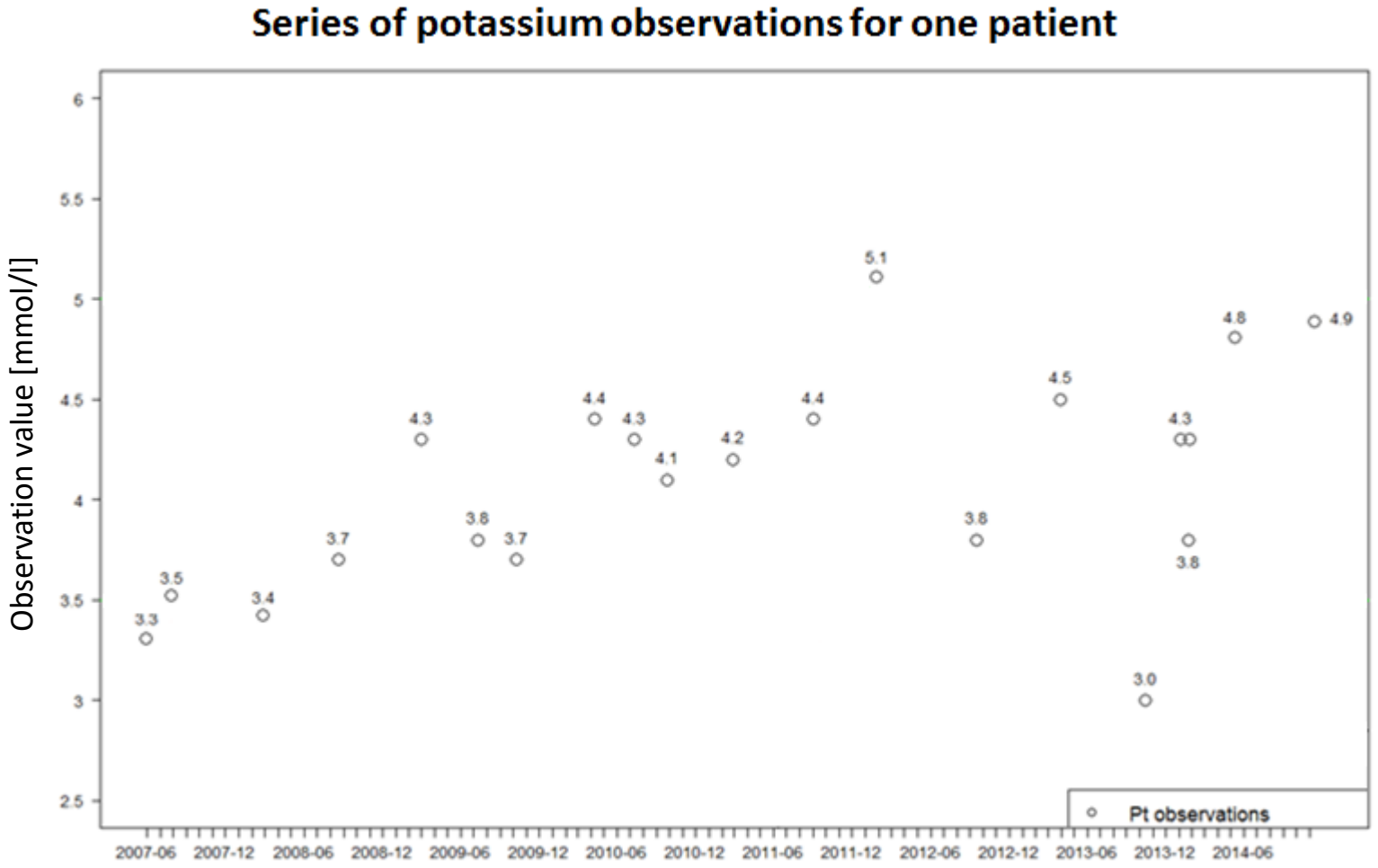
Background

- Most clinical decisions involve lab results.
- Failure to follow up laboratory test results is a major concern in primary care.
- Electronic Health Records (EHRs) can support General Practitioners (GPs).
- GPs spend ~1 hour per day processing alerts.



Alert fatigue and **patient safety issues**

Example



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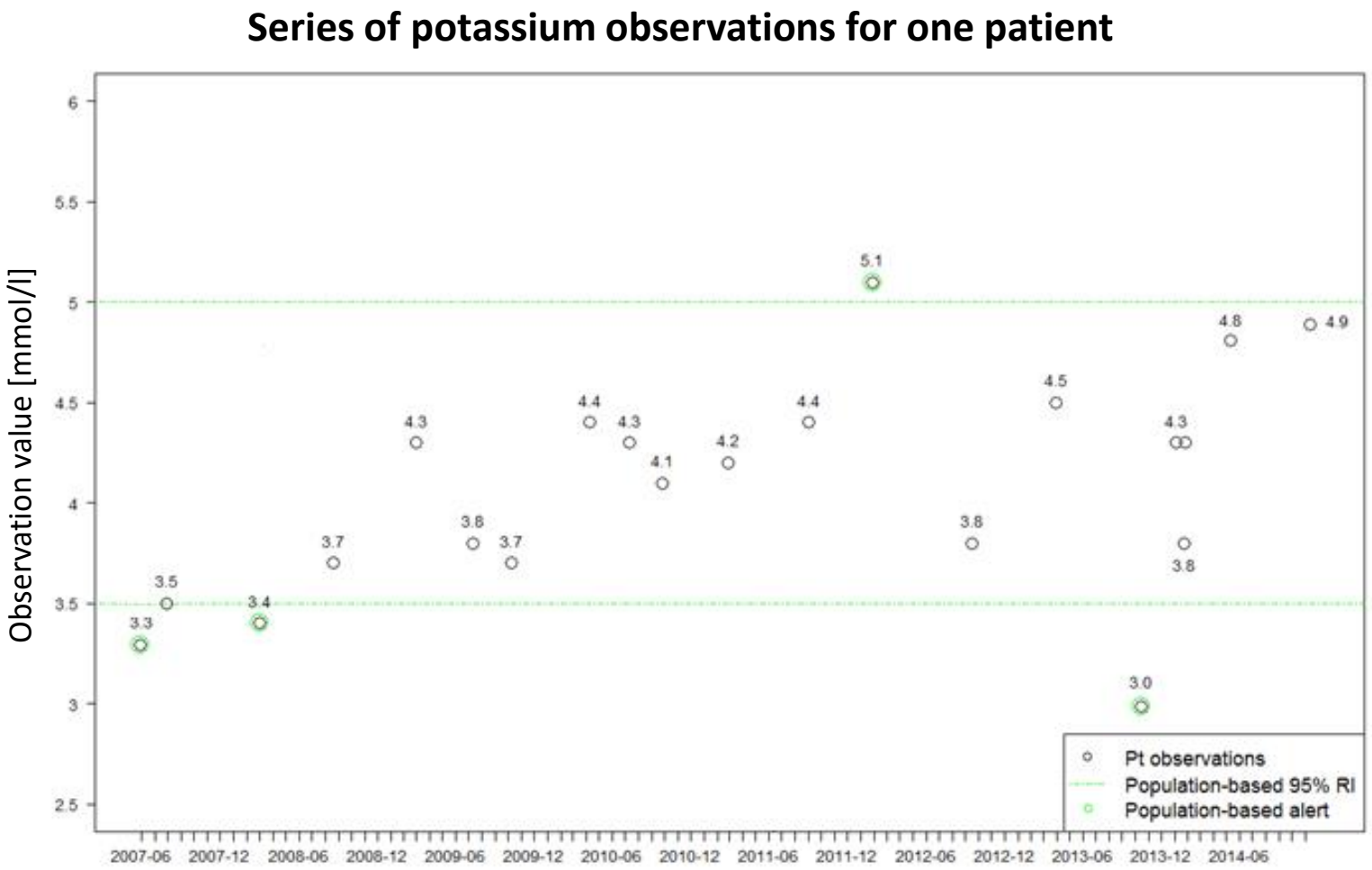
Population-based reference intervals



Methods: Mixed-effects model

If $y_{ij} \sim N(\alpha_i, \sigma^2)$, $\alpha_i \sim N(\mu, \omega^2)$, *then* $\alpha_i \mid \bar{y}_{ij}, \sigma^2, \mu, \omega^2 \sim N(\tilde{\mu}_{ij}, V_{ij})$ *where*

$$\tilde{\mu}_{ij} = \frac{\mu\omega^{-2} + \bar{y}_{ij}\frac{n_{ij}}{\sigma^2}}{\omega^{-2} + \frac{n_{ij}}{\sigma^2}} \quad \text{and} \quad V_{ij} = \left(\omega^{-2} + \frac{n_{ij}}{\sigma^2}\right)^{-1}$$

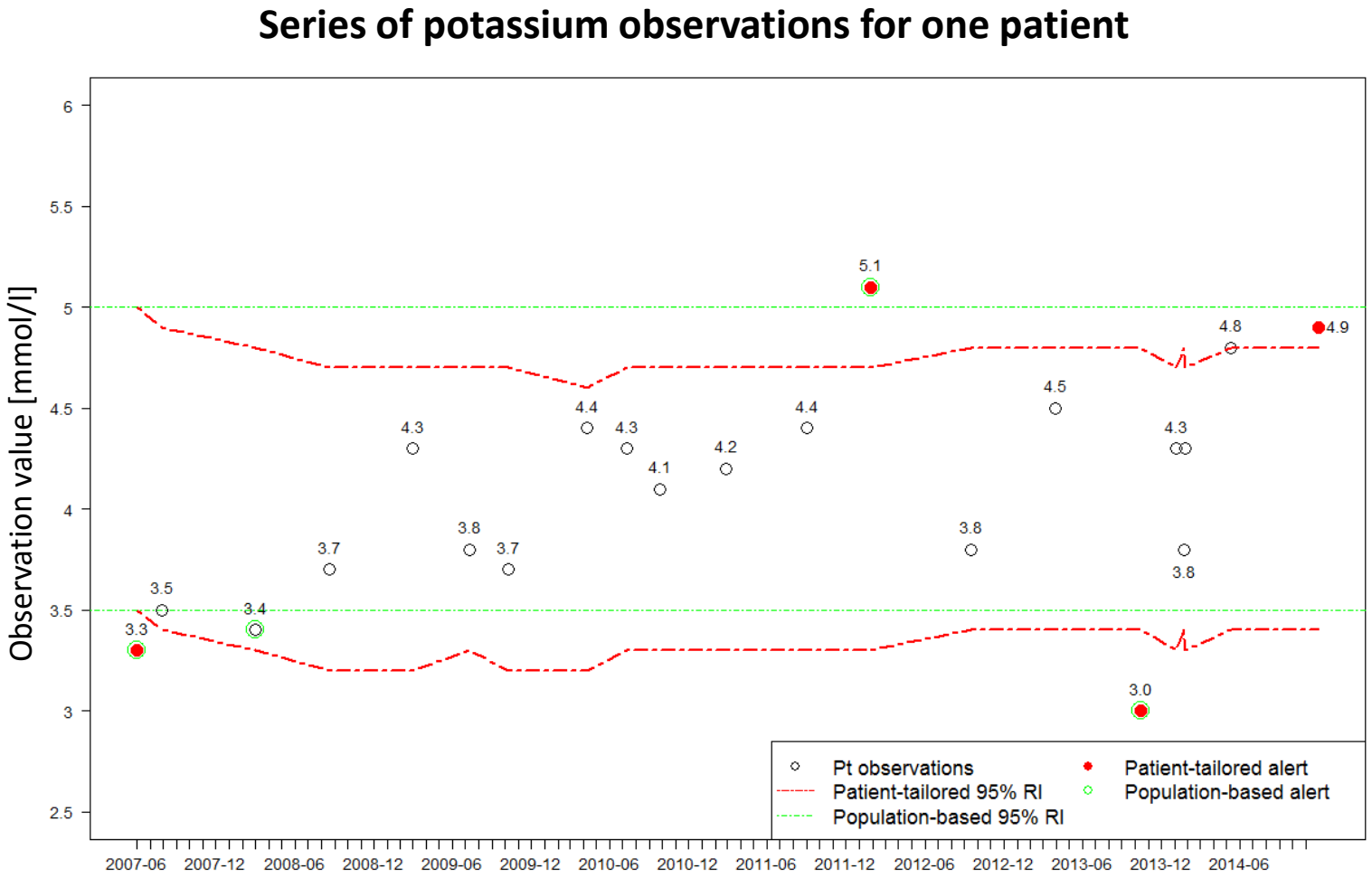
Equivalently,

$$\tilde{\mu}_{ij} = \mu\lambda_{ij} + (1 - \lambda_{ij})\bar{y}_{ij} \qquad (1)$$

$$\lambda_{ij} = \frac{\omega^{-2}}{\omega^{-2} + \frac{n_{ij}}{\sigma^2}} = \frac{\frac{\sigma^2}{n_{ij}}}{\omega^2 + \frac{\sigma^2}{n_{ij}}} = \frac{V_{ij}}{V_{ij} + \omega^2} \qquad (2)$$

- μ and ω^2 are population mean and variance;
- y_{ij} is the jth observation of patient i;
- α_i is the mean of patient I;
- σ^2 is the intra-patient variance;
- $\bar{y}_{ij}$ and n_{ij} are the sample mean and number of observations for patient i after j observations;
- $\tilde{\mu}_{ij}$ and V_{ij} are the maximum likelihood estimates of α_i and σ^2;
- λ_{ij} is a shrinkage factor.

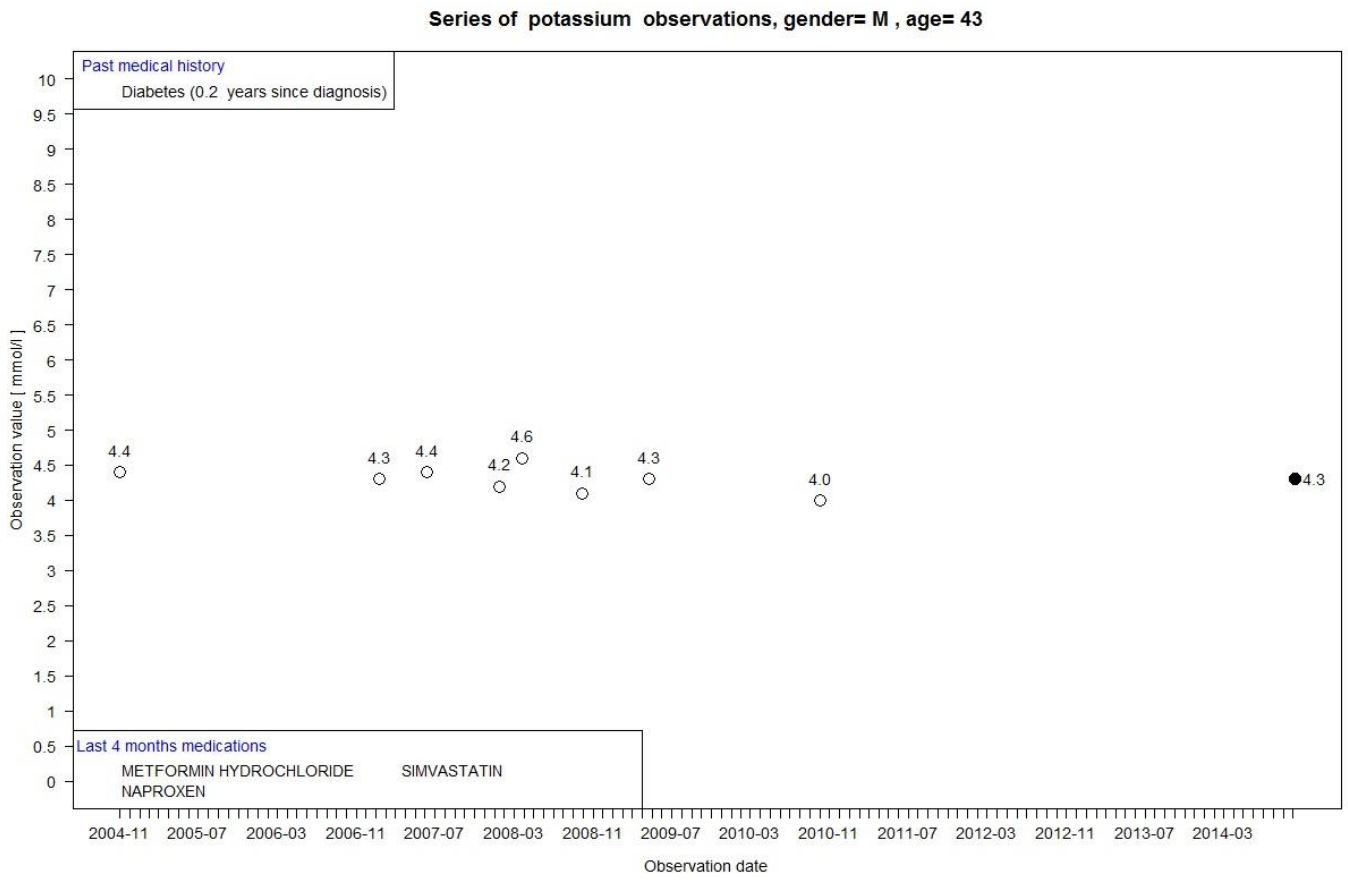
Mixed-effects model: Example on patient data



Methods: data source and study design

- Salford Integrated Record database (population ~234k, UK).
- Registered patients aged 18-85 between 1990-2012.
- Potassium measurements.
- Training dataset ~150k patients.
- Test dataset 500 patients.
- Clinical relevance of alerts assessed by a survey administered to GPs (gold standard).

Survey



What colour this value (black dot) should be flagged?

- ☐ Green (normal value; i.e. no actions required)
- ☐ Yellow (probably abnormal; i.e. repeat in more than a week, do further test, change medication)
- ☐ Red (definitely abnormal; i.e. repeat urgently, hospital admission)

Survey: respondents characteristics

- Survey administered to 43 GPs in Manchester (UK)
- Response rate 44% (19 out of 43)
- Each value was assessed by a median of 3 GPs

Respondent characteristic	Reply	N (%)
Days per week in practice	1-3 days	10 (52.6%)
	4-5 days	9 (47.4%)
Years of experience	<10 years	2 (10.5%)
	10-20 years	5 (26.3%)
	>20 years	12 (63.2%)
Opinion about tests alerts in general practice	Not enough	4 (21.1%)
	About right	7 (36.8%)
	Too much	8 (42.1%)

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Results: Alerts prevalence, PPV and sensitivity

Parameter	Standard method	Patient-tailored method	Combined method
Prevalence (N) in test dataset (n=4,144)	11.3% (470)	9% (372)	7.3% (301)
Prevalence (N) in values assessed by GPs (n=152)	50% (76)	50% (76)	25% (38)
Sensitivity	0.51	0.41	0.38
PPV	0.66	0.67	0.76

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Results: Mixed-effects logistic regression

Parameter	Adjusted OR [95% CI]
Standard method pos. vs neg.	24.5* [5.3,113.7]
Patient tailored method pos. vs. neg.	6.2* [2.0,19.1]
Weekly working days in GP: 4-5 days vs 1-3 days	2.2 [0.4,11.3]
Years of experience in GP: 10-20 years vs <10 years	3.5 [0.4,11.3]
Years of experience in GP: >20 years vs <10 years	6.0 [0.3,103.1]
Opinion about tests alerts in GP: not enough vs about right	0.5 [0.7,3.7]
Opinion about tests alerts in GP: too much vs about right	0.2 [0,1.3]

Estimated variance of the random effects:

- assessor: 1.5 (SD:1.2)
- value: 0.4 (SD: 0.6)

*statistically significant

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Conclusions

Conclusions:

- personalising alerts for lab results could provide useful information to clinicians;
- by combining both methods together systems could be used to prioritise alerts.

Future work:

- introduce time-dependency;
- extending evaluation to other lab tests (i.e. eGFR, calcium, creatinine);
- further alert personalisation with info in EHR (i.e. age, gender, comorbidities ecc).

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Presented project
in collaboration with

Thanks for your attention

A partnership between

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