Newcastle Allotments Lead Biomonitoring Study (NABS) Update

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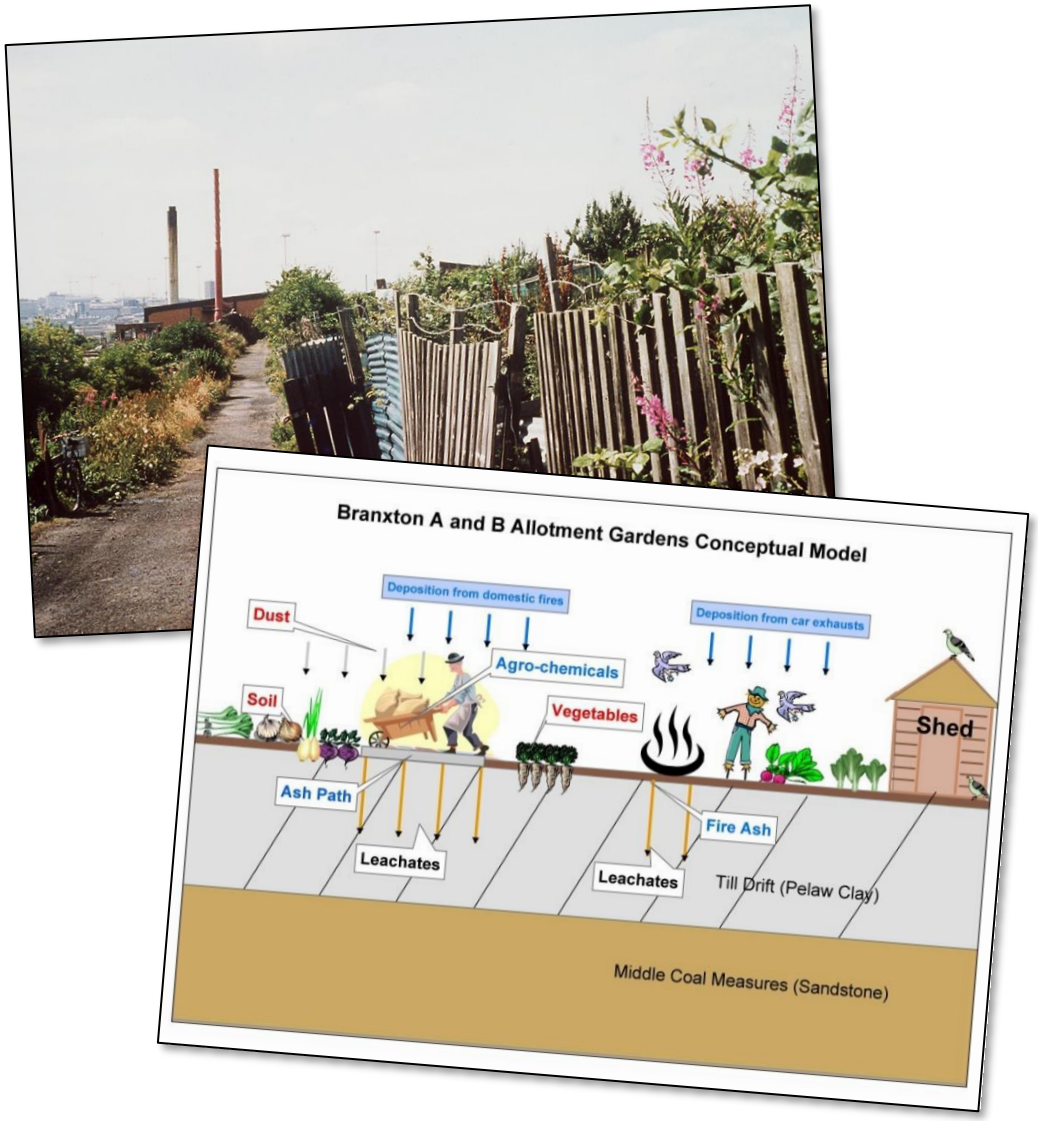
THE STORY SO FAR…

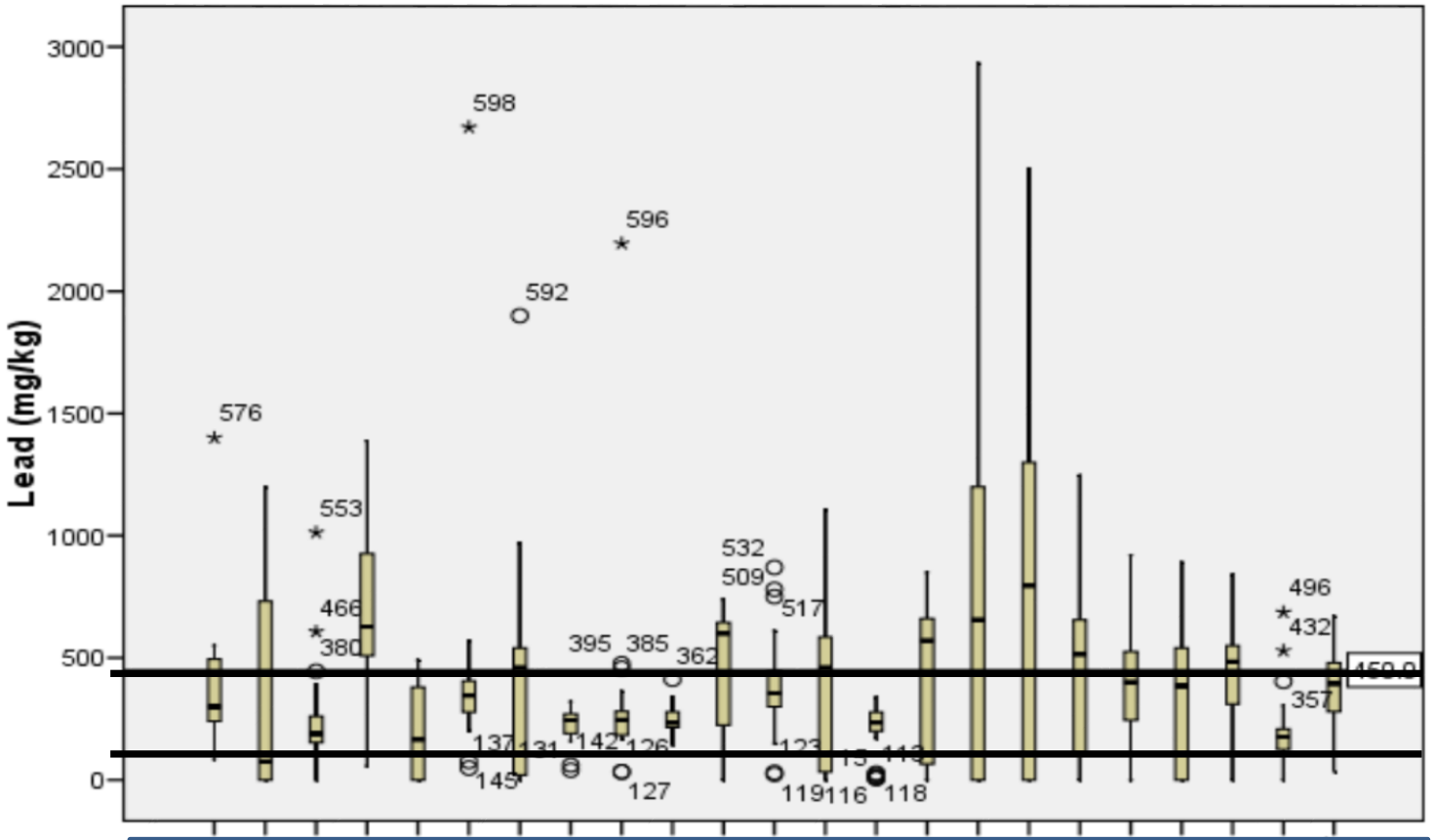


Coal ash

Old window frames

Bonfires

Total lead in Newcastle allotment top soils



Previous UK allotments soil guideline value **450 mg/kg**

New (2014) UK allotment soil guideline value C4SL **80 mg/kg**

Adverse Health Effects of Lead Exposure

Death

Encephalopathy
Nephropathy
Frank Anaemia

Increasing evidence to suggest even low levels of environmental Pb exposure in adults contributes to:
chronic kidney disease,
hypertension
spontaneous abortion in females

Developmental toxicity: delayed puberty; decreased growth & hearing

Developmental toxicity

decreased IQ and academic abilities
Attention-related disorders
Anti-social behaviours

Aim: To improve the derivation of soil assessment criteria to give greater confidence to regulators

- Measure and compare Pb and Zn protoporphyrin (ZPP) in blood of gardeners and their non-gardening neighbours (the controls)
- Measure Pb levels in saliva to investigate its potential as an alternative biomonitoring matrix
- Determine participants home grown fruit and vegetable consumption patterns, and frequency and duration of time spent on the allotment
- Determine the uptake of Pb across a range of typical allotment produce
- Characterise the risks associated with urban allotment gardening through modelling

Newcastle Allotments Lead Biomonitoring Study

METHODS

Study Design: Conceptual Exposure Model

Factors?

Gender?

Age?

Behaviours?

Age?
Osteoporosis?

Pathways

Lead sources

Samples Collected

Ingestion

Inhalation

Diet

Soil

Dust

Allotment

Home

Work & Hobbies

- Garden Soil
- Garden vegetables
- Tap water
- House dust
- Atmospheric deposition

- Exposure questionnaire
- Food frequency questionnaire

Internal exposure/ body burden

- Blood
- Saliva

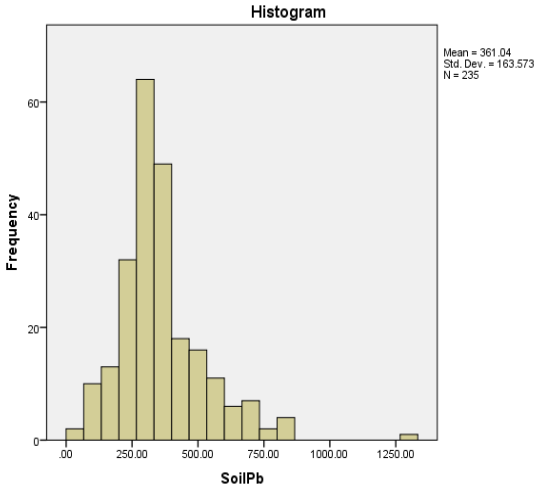
Modelling

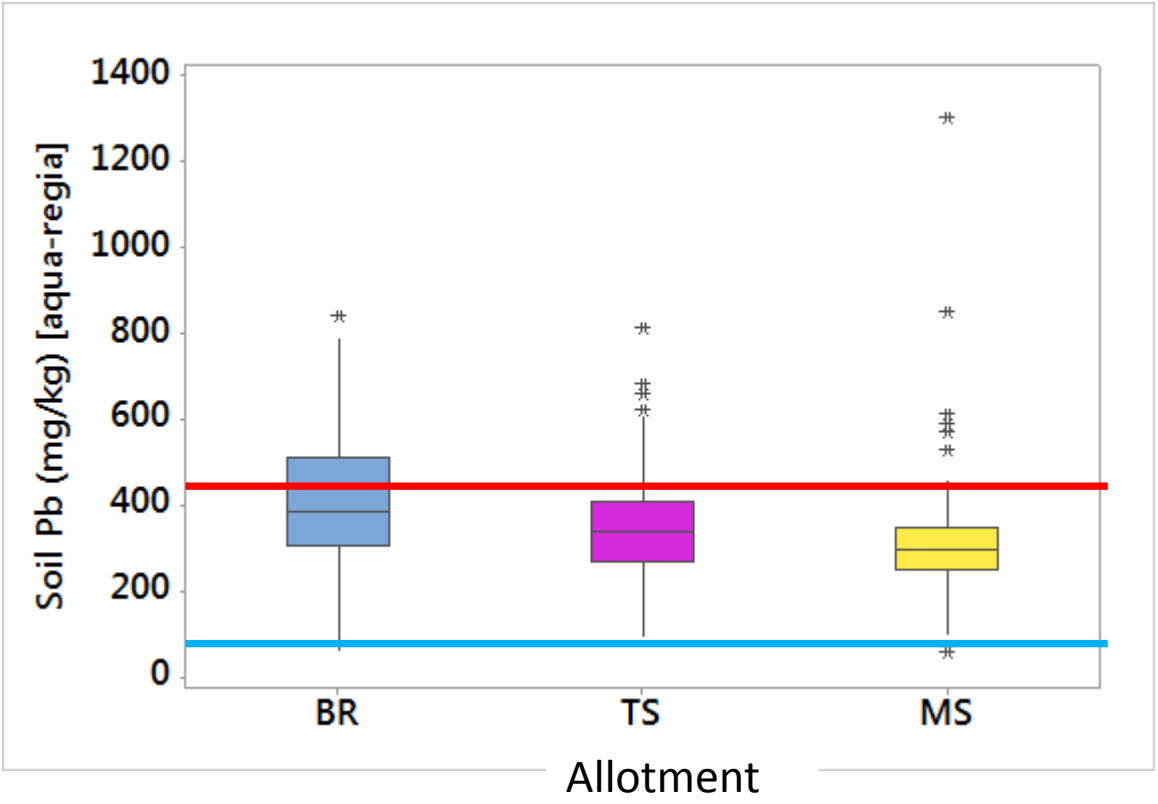
Regression analysis	To identify the predictors of blood lead
Carlisle-Wade Equation	Adult BLL = food exposure x f + soil/dust Pb concn x f + air Pb concn x f
UK Contaminated Land Exposure Assessment Model	Conceptual exposure model represented by a series of equations and associated input parameter values. Derives a soil Pb screening value based on child exposure.

Newcastle Allotments Lead Biomonitoring Study

RESULTS

Exposure to Pb: **Allotment Soil**



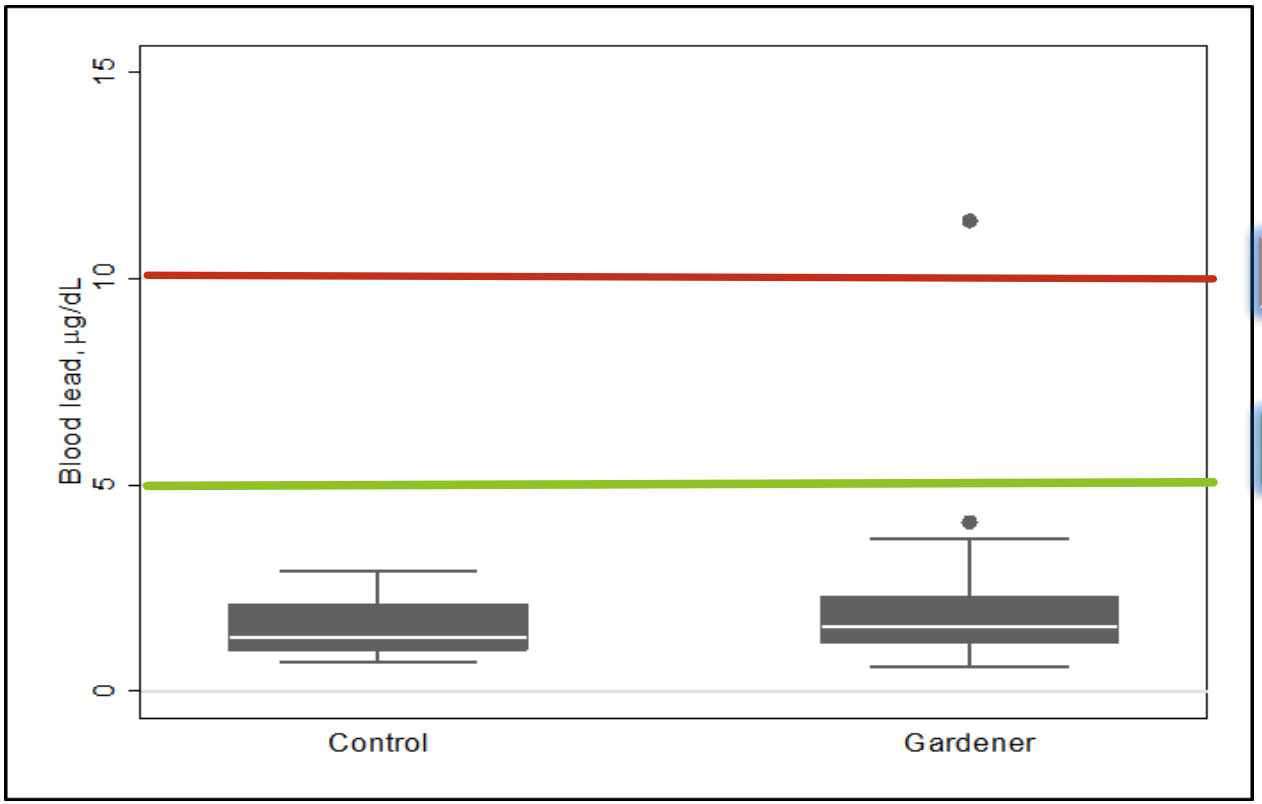


Former UK allotment SGV **450 mg/kg**

New (2014) UK allotment C4SL **80 mg/kg**

Range: 58 – 1300 mg/kg
BR (mean= 403 mg/kg); n=86
TS (mean= 360 mg/kg); n=86
MS (mean= 312 mg/kg); n=101

Blood lead concentrations (µg/dL)



UK BLL (1970's)

Critical Con. set in our study

3 allotment sites

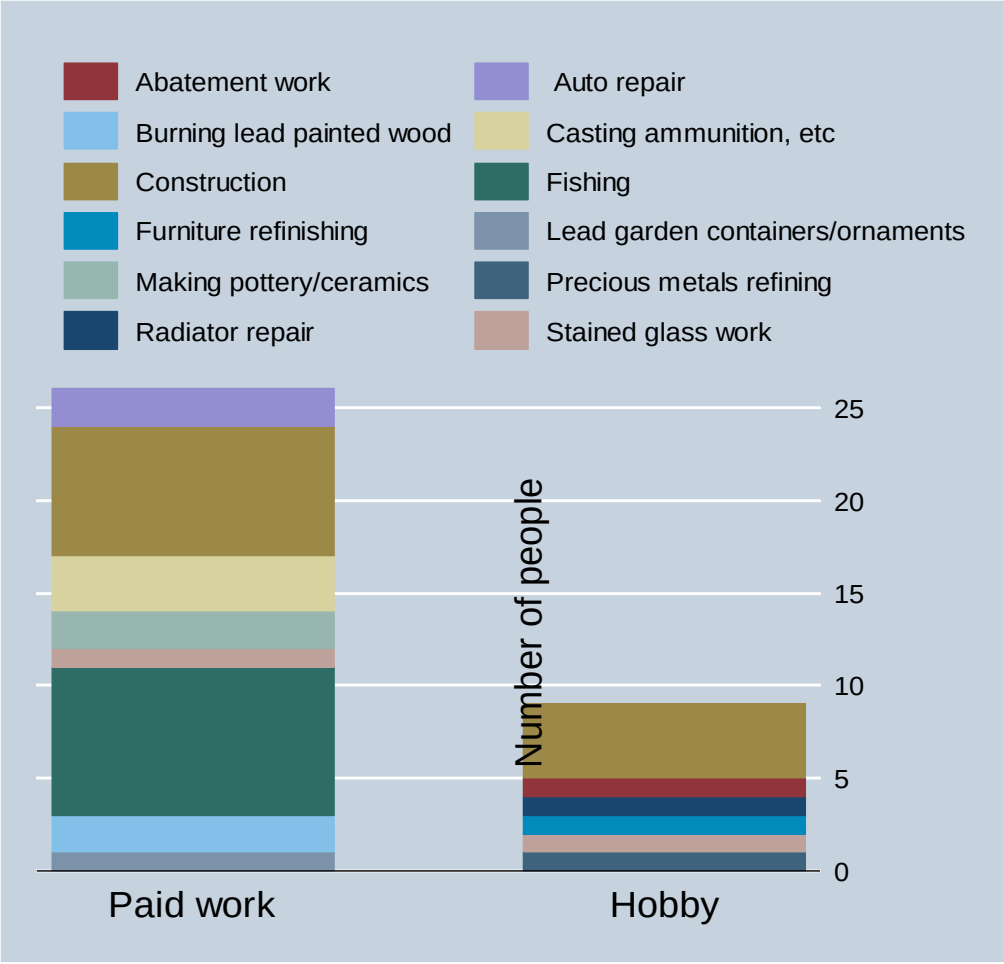
73 participants, 43 gardeners and 30 controls, two thirds of both G & C were women.

Two thirds of our gardeners were aged between 40 and 60

Exposure to Pb:
Personal factors/Behaviours in Regression Model

Indicative list of topics covered:

- **Age**
- **Years of allotment gardening**
- **Smoking status**
- **Units of alcohol**
- **Gender –** 61% female
- **Bite nails (hand top mouth behaviour) –** 22%
- **Wash hands before eating on site**
- **Peel roots & tubers**
- **Wash fruit & veg**
- **Visit allotment: frequency**
- **Visit allotment: visit duration**



Questionnaire data:
Home characteristics & Behaviours
Food Frequency Survey

Results from the 'best' regression model, after adjustment for self-reported exposure factors, showing predictors of BLL

Predictors/Explanatory variables	p-value
Gardener (compared to control)	**0.000**
Number of years with an allotment	**0.012**
Soil lead level (for those with allotments)	**0.036**
Fraction of **root vegetables** home produced	**0.012**
Fraction of **green vegetables** home produced	0.060
Fraction of **herbaceous fruit** home produced	0.058
Fraction of **tree fruit** home produced	0.063
Fraction of **shrub fruit** home produced	0.565
Fraction of **tuber vegetables** home produced	0.238

The regression started by including all possible explanatory variables. The 'best' regression model was selected based on the lowest AIC (Akaike's Information Criterion) value. If the AICs of two models differed by less than 3, the model with the lower BIC (Bayesian Information Criterion) value was selected.

Comparing the Exposure Assessment Model (UK CLEA) assumptions with NABS findings

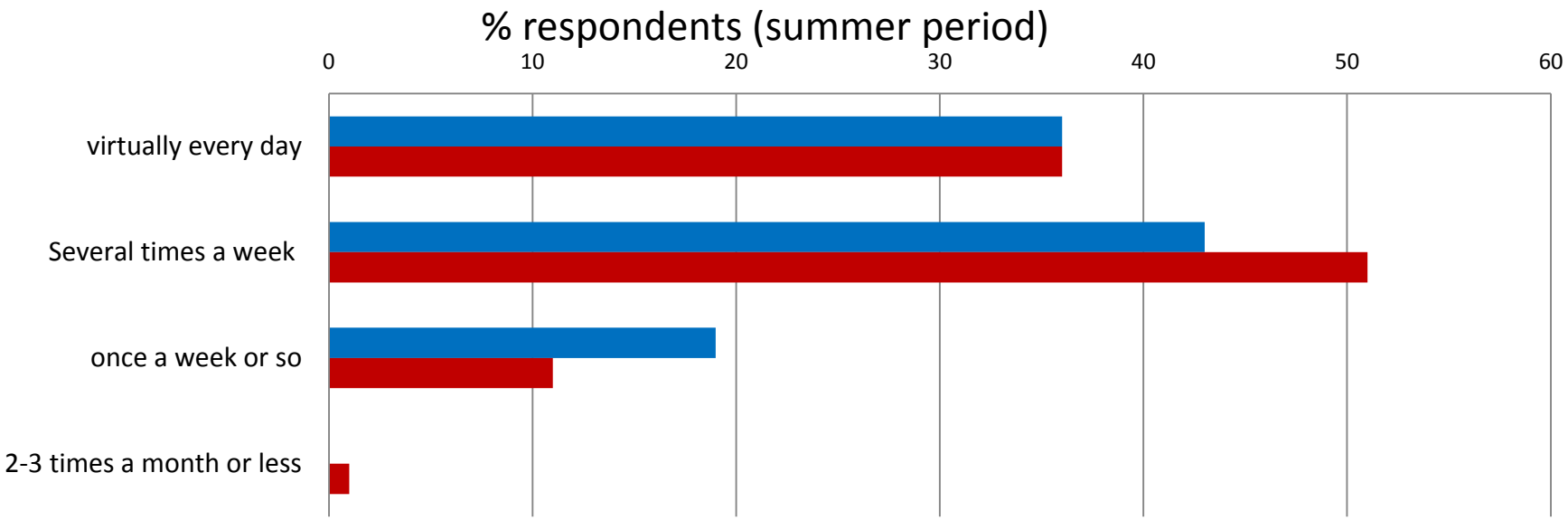
i. **BEHAVOURS:** frequency/duration on site

ii. **PRODUCE Pb:** soil to plant concentration factors

iii. **DIET:** consumption rate and % homegrown

i. BEHAVOURS

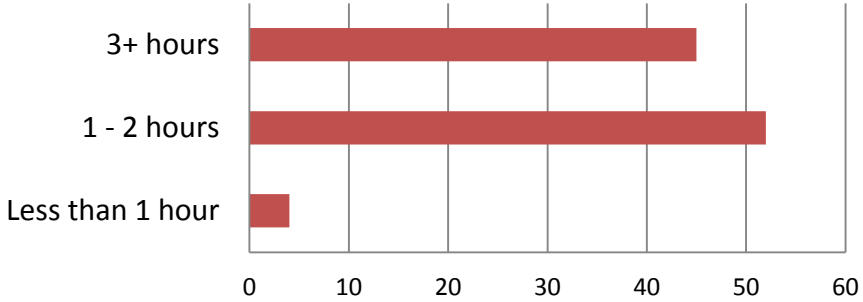
CLEA comparisons: Visit frequency



	2-3 times a month or less	once a week or so	Several times a week	virtually every day
NABS	0	19	43	36
Saunders (1993)	1	11	51	36

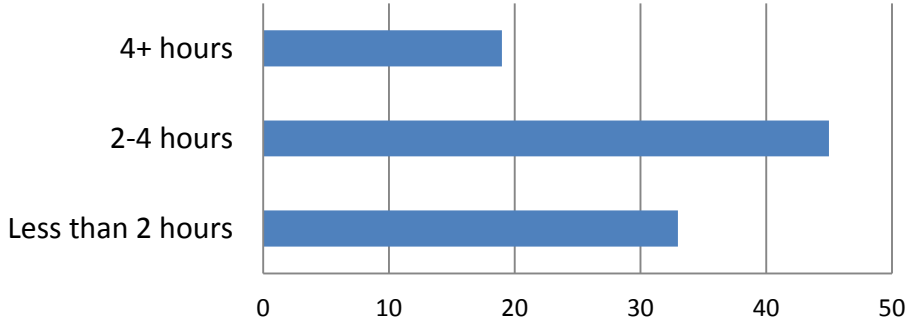
CLEA comparisons: Visit duration

UK CLEA (from Saunders, 1993)



	Less than 1 hour	1 - 2 hours	3+ hours
Saunders (1993)	4	52	45

NABS

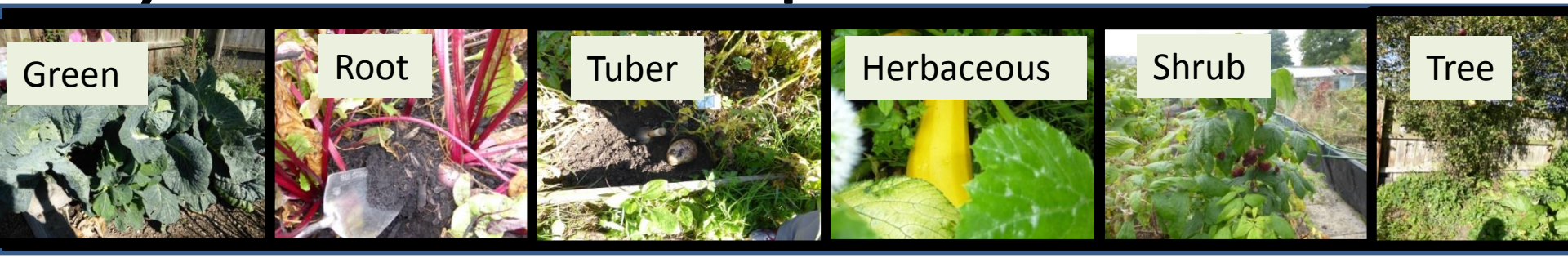


	Less than 2 hours	2-4 hours	4+ hours
NABS	33	45	19

NABS data supports CLEA assumptions on allotment visit frequency and duration

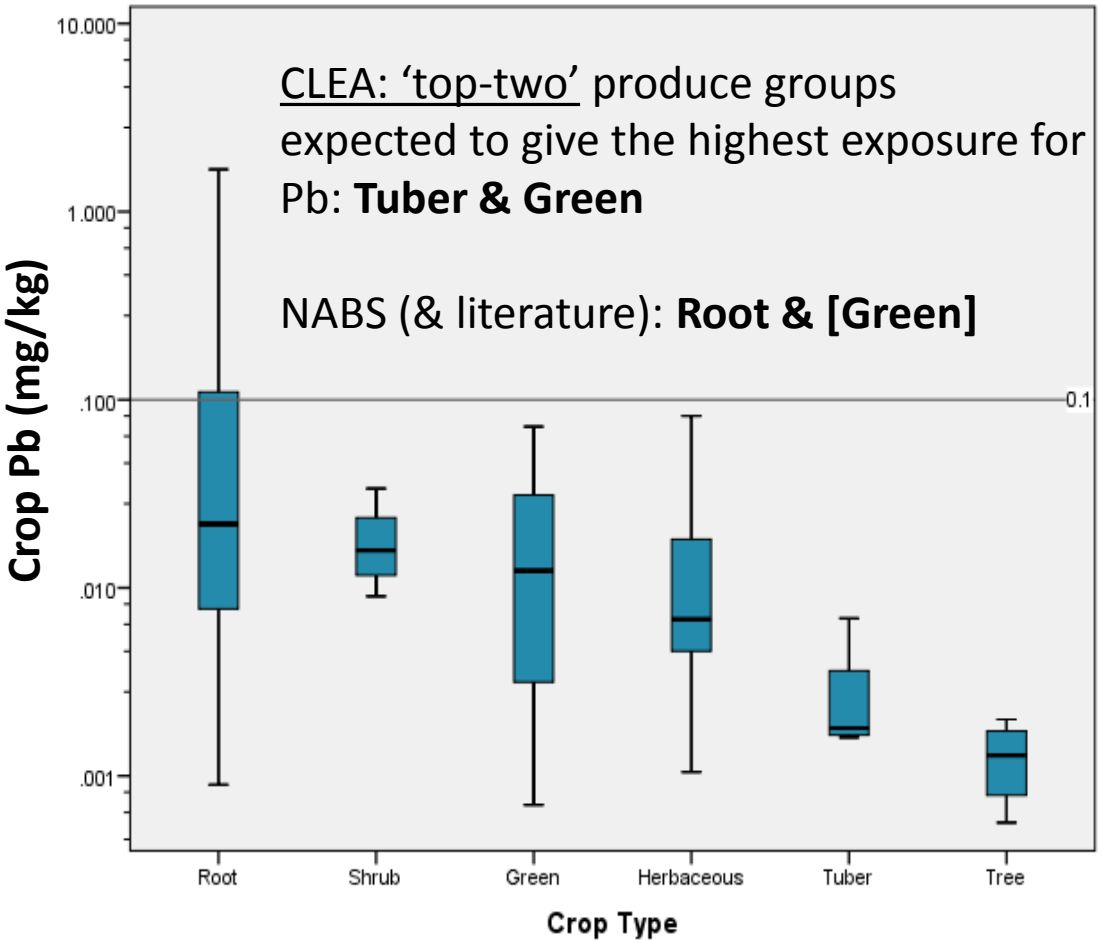
Exposure to Pb:

ii) Produce Pb & soil to plant concentration factors

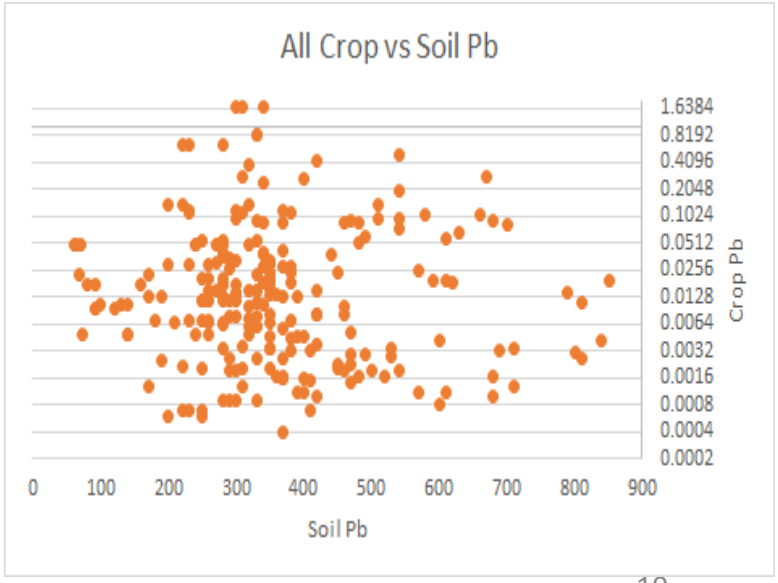


		NABS examples
Vegetable	Green	**Low growing leafy vegetables** *e.g. lettuce, chard, cabbage (red, white, greens, kale)*
	Root	**Storage root crops** *e.g. beetroot, carrot, leeks, rhubarb*
	Tuber	**Tubers** *e.g. Potatoes*
Fruit		**Fruit and Seed crops**
	Herbaceous	*e.g. courgette, tomatoes*
	Shrub	*e.g. blackcurrants, raspberries*
	Tree	*e.g. apples*

Exposure to Pb: **Allotment Produce**



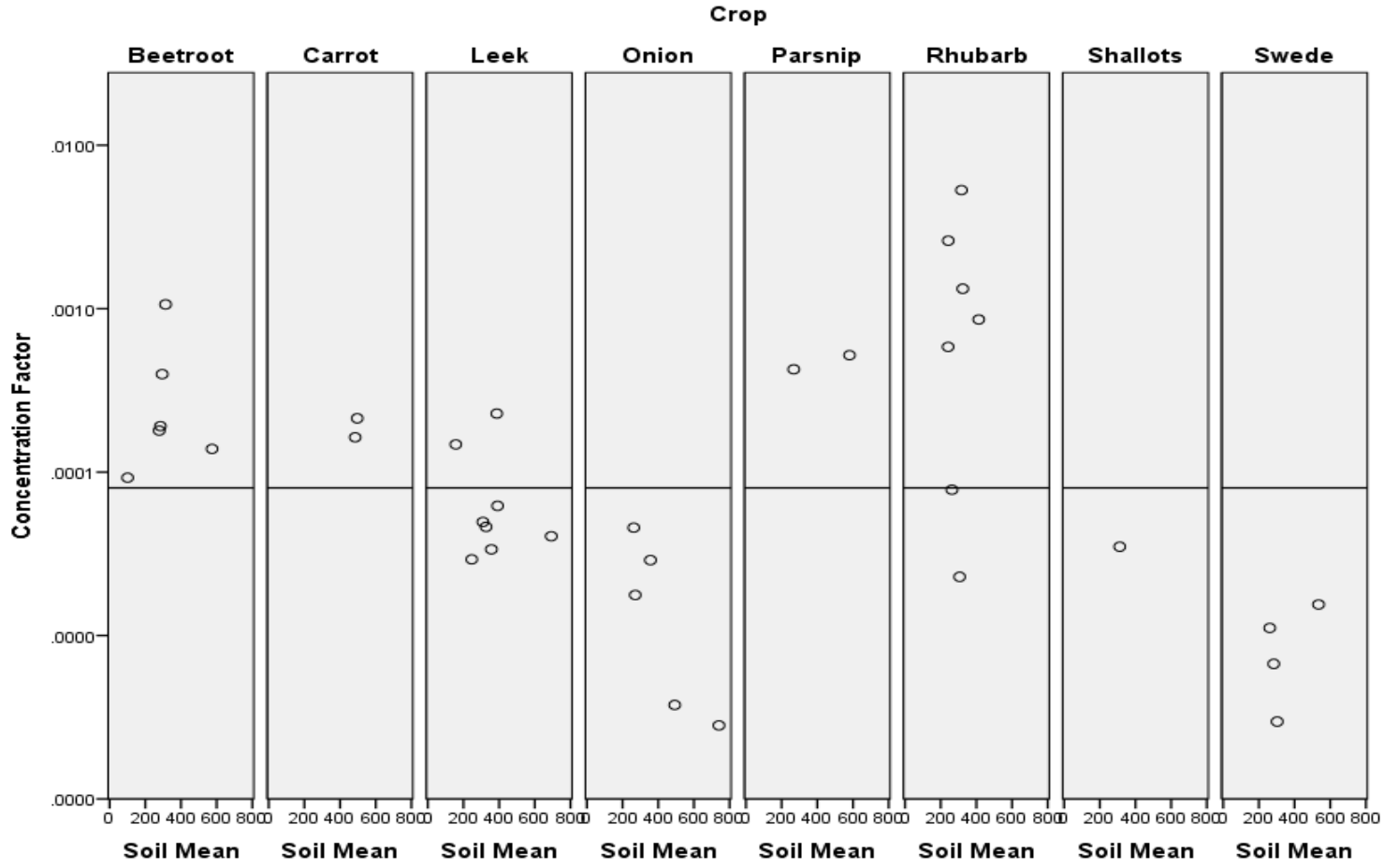
Root Veg	Mean Pb (mg/kg)	n
Beetroot	0.1071	6
Carrot	0.0925	2
Onion	0.0062	5
Parsnip	0.2077	2
Rhubarb	0.4661	7
Shallots	0.0109	1
Leek	0.0267	8
Swede	0.0035	4



FAO/WHO-CODEX 1995, 2010 amendment:
0.1 mg/kg FW for root, tuber and fruiting vegetables
0.3 mg/kg FW for green vegetables

Soil to plant concentration factors

CLEA: uses SPCF to estimate the relationship between the concentration of the contaminant in the plant in relation to the concentration in the soil. Empirically derived rather than modelled.



Root Veg geomean

Soil to plant concentration factors

	Soil to plant concentration factor (Geomean)	
	CLEA (Plant FW/Soil DW)	NABS (Plant FW/Soil DW)
Tuber	**0.00731**	0.00000488 (4)
Green veg	0.00419	0.0000337 (33)
Root veg	0.00402	**0.0000885** (35)
Herbaceous fruit	0.000749	0.0000443 (10)
Tree fruit	0.000229	0.00000372 (4)
Shrub fruit	0.000205	0.0000534 (4)

CLEA: Tuber >> Green > Root >> Herbaceous >> Tree > Shrub
NABS: Root >> Shrub > Herbaceous > Green >> Tuber > Tree

- CLEA: 'top-two' produce groups expected to give the highest exposure (conc and consumption rate) for Pb: **Tuber & Green**

- NABS (& literature) suggest > Pb concentration in **Root**

NABS data doesn’t support CLEA on soil to plant transfer factors

Exposure to Pb:
iii) consumption rate

Recent CLEA update - reduced the modelled consumption rate to 50th percentile, except for the 'top-two' produce groups expected to give the highest exposure for Pb: **Green & Tuber**

		Vegetable consumption rate (g fw kg^{-1} bw day^{-1})			Fruit consumption rate (g fw kg^{-1} bw day^{-1})		
	Source	Green	Root	Tuber	Herb.	Shrub	Tree
Gardener	NABS	2.46	2.17	2.44	2.48	0.71	2.29
CLEA (adult)	**UK NDNS ***	**2.36 (90th)**	1.12 (90th)	**2.35 (90th)**	1.29 (90th)	0.18 (90th)	2.38 (90th)

NABS data suggests increasing assumptions in CLEA for root/herb/shrub produce consumption rates
Note: 2x more root veg in diet

Consumption rate (g fw kg^{-1} bw day^{-1})=
Portion size x daily portions for individual foods x std UK body weight.
The produce was then grouped together in the same food groups.

*UK NDNS – UK National Diet and Nutrition Survey

Exposure to Pb:
iii) %homegrown

		% homegrown consumed	
		CLEA data	NABS (gardeners) data
		High end (P90)	High end (P90)
Vegetables	green	**33**	71
	root	**40**	61
	tuber	**13**	95
Fruit	herbaceous	**40**	79
	shrub	**60**	100
	tree	**27**	54

- **NABS data suggest a higher % HF would be preferable to be suitably precautionary.**

NABS - Summary so far ……

There is evidence of a relationship between BLL and allotment gardening

BLL <5 ug dL – suggest current soil screening value over protective (for adults)

SPCF – their use needs a re-think

Root vegetables need greater focus in particular (as higher Pb)

NABS Next steps…..

Modelling of adult blood Pb using Carlisle-Wade
[food exposure – done for HG now need to add bought]

Additional CLEA modelling
[SSAC now 170 mg/kg]

SPCF factors

Children's exposures

Newcastle Allotments Lead Biomonitoring Study

Allotments Working Group,
Environment Agency,
WCA Environmental,
Food Standards Agency,
Independent Experts

THANK YOU!

Northumbria University,
Newcastle University,
Newcastle City Council,
Health & Safety Laboratory