Determining Pesticide Mixtures And Exposure Clusters Using Urinary Biomarkers In Children From The Rural Western Cape

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Introduction

Children in agricultural communities are especially **vulnerable to pesticide exposure** due to their developing physiology and behaviours[1-4]. In South Africa, little is known about long-term pesticide **exposure patterns** in children, and even less about real-life chemical mixtures in low- and middle-income settings. **Innovative** visualisation techniques such as **network analysis** and **community detection** offer powerful tools for understanding co-exposure patterns[5].

Aim

By drawing on data from the longitudinal *Child Health Agricultural Pesticide Cohort Study in South Africa* **(CapSA)**[6], this **cross-sectional sub-analysis** aims to explore **clustering and mixture patterns** of urinary pesticide metabolites in children in the rural Western Cape.

Methods

Study participants: **193 children** who provided **urine samples** across **five sampling rounds (2017–2019)**.

Study area: **2 agricultural hubs** in the Western Cape, namely **Grabouw (pomme fruit)** and **Piketberg (wheat)**.

Dataset: **Urinary pesticide biomarkers (n=14)** detected in at least one sample; **exposure data** collected via **interviews**.

Pesticide groups include:

- **Insecticides** – organophosphates (OP) & pyrethroids (PYR);
- **Fungicides** – carboxamide (CARB), dithiocarbamate (DITH) & triazoles (TRI);
- **Herbicide** – phenoxy acid (ACID)

Analysis: Pearson correlation **heatmaps**, **network estimation** and **comparative network analysis** (to be completed).

HREC Reference: **651/2025**

Preliminary Results

1. Study Area

40% of participants reside in **Grabouw**

60% of participants reside in **Piketberg**

2. Study Population

Biological Sex

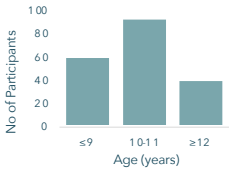
49% **51%**

Type of Residence

46% **54%**

Age

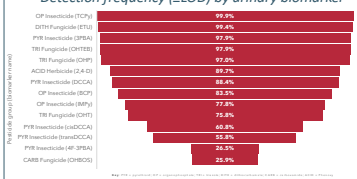
Distribution of Participants by Age Group



Median age: **10 years** (IQR: 10-11years)

3. Pesticide Biomarkers

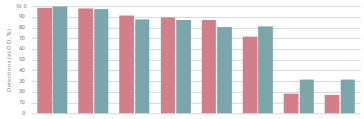
Detection frequency (≥LOD) by urinary biomarker



High overall detection across pesticide classes

- 10/14 biomarkers detected in **>70%** of samples
- Insecticides (OP & PYR) and fungicides (TRI & DITH) **>95%**
- Indicates **ubiquitous exposure** in the cohort

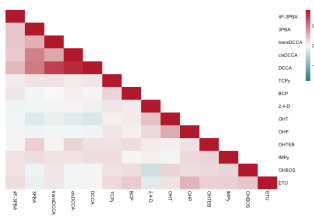
Detection frequency by area (selected biomarkers)



Fluorinated pyrethroid insecticide (4F-3PBA) and carboxamide fungicide (OHBOS) markers are much **lower** in Grabouw than in Piketberg

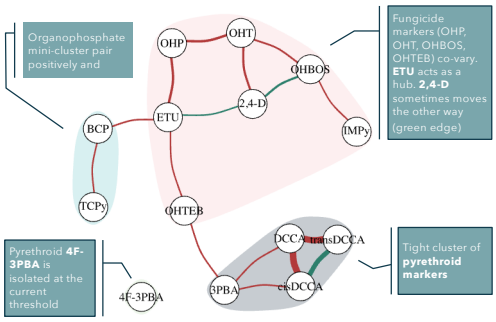
4. Network Analysis

Pearson correlations among ln-transformed urinary pesticide biomarkers



- Strongest links are within the **pyrethroid insecticides** (cis/ trans-DCCA, DCCA, 3PBA, 4F-3PBA)
- **Triazole fungicides** (OHTEB, OHP, OHT) show moderate correlations; **organophosphates** are weak overall.
- The **herbicide 2,4-D** is mostly independent (often near-zero or negative).

Community-detected partial-correlation network of urinary pesticide biomarkers



Community detection reveals three groupings: **a tight pyrethroid cluster**; a **fungicide/ETU group** with ETU as a hub; and a **small OP pair** linked weakly to the others. The herbicide 2,4-D behaves largely independently. Lines show direct relationships after controlling for all others (**red = positive**, **green = negative**; thicker = stronger; shaded areas = groups)

Discussion

- The **high overall detection** of most urinary biomarkers suggests **frequent and recent pesticide exposure** as most pesticides are excreted from the body within 48hours[4,7]. Exposure routes include ingestion, inhalation and dermal contact, through both recreational and farming activities.
- 4F-3PBA OHBOS detections **much lower** in Grabouw than in Piketberg, reflecting **local pesticide use patterns.**
- Pyrethroid metabolites (3PBA; cis-/trans-DCCA; DCCA) **correlate most strongly**, which is expected given shared parents and the cis/trans isomers. 4F-3PBA is **more specific** and points to exposure from **fluorinated pyrethroid products**[7,8].
- The organophosphate mini-cluster may indicate **co-use periods**, while the phenoxy acid herbicide acts largely independently, suggesting **distinct application processes** and **pathways** (e.g., applied to soil, not directly to plants)[7,8].
- Strengths = **multiple urine samples** collected over two years; limitations = **non-first morning void** samples.

Conclusion

- Using ***innovative*** network methods, this study will map pesticide mixture patterns in exposed children.
- Findings may inform public health strategies, enable ***adaptive***, community-specific interventions, and support ***sustainable*** pest management.
- Next steps: **comparative network analysis across strata** (e.g., age, residence, spray round)

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