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Summer School on Multidimensional Poverty Analysis

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Oxford Department of International Development
Queen Elizabeth House, University of Oxford

Tabita, Kenya



Rabiya, India



Stephanie, Madagascar



Agatha, Madagascar



Dalma, Kenya



Ann-Sophie, Kenya



Valérie, Madagascar



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Associations across Deprivations

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Where we are...

We have defined:

- Purpose
- Unit of Analysis
- Dimensions

Then we took a pause and described the data, before defining

- Indicators
- Deprivation cutoffs

Today we will

Now, we take another pause, to describe and understand the associations between deprivations, before

- Reconsidering our selection of indicators
- Defining the categorization of indicators into Dimensions
- Defining tentative weights for trial measures

Why this pause?

To identify 'redundancy'

To see which indicators are highly associated
which indicators have low associations

What might you do based on an analysis of associations?

- Drop or modify weights on highly associated indicators
- Combine some indicators into a sub-index
- Adjust your categorization of indicators into dimensions.

Multidimensionality & Association

View 1: High association favoured

- **Traditional composite marginal** measures
 - Aggregate indicators having high association
 - to generate a **robust** measure.
 - Do not include indicators having low association
- (Saisana, M., A. Saltelli, and S. Tarantola 2005, Foster, McGillivray, and Seth, 2012; *Handbook of Composite Indicators*; OECD, 2008, Giuo *et al.*)

Multidimensionality & Association

View 2: Low association favoured

- **High correlation signals redundancy**
- redundant indicator(s) could be dropped
- **Low redundancy** – justifies multidimensional measure
(Ranis, Samman, and Stewart, 2006; McGillivray and White, 1993)

Multidimensionality & Association

Our view: not one or the other

- Value judgements are a fundamental element
- **If indicators are highly associated**, both may be retained for **normative/policy** reasons, or because their reduction over time differs
- **If indicators have a low association**, both may be retained if each is **independently important**

Sources of information

To study the “association”/similarity across deprivation indicators we will:

- Focus on dichotomised deprivation scores, 0 or 1.
- Use **two** different **sources** of information:
 - Uncensored deprivation scores
 - Censored deprivation scores

This class will:

- Explain limitations of correlation analysis
- Introduce measure of redundancy: measure of overlap

Definitions

Association for dichotomous variables - strength & direction

Similarity for dichotomous variables – strength

Similarity Coefficients in the Literature

There is an extensive list of binary similarity coefficients.

Hubalek (1982) surveys 43 similarity coefficients for binary/dichotomous data

Two simple and very intuitive ones are:

a) The Simple Matching Coefficient - SM

Sokal & Sneath, (1963)

b) The Jaccard Coefficient – J

Jaccard, (1901); Sneath, (1957)

Describing Associations

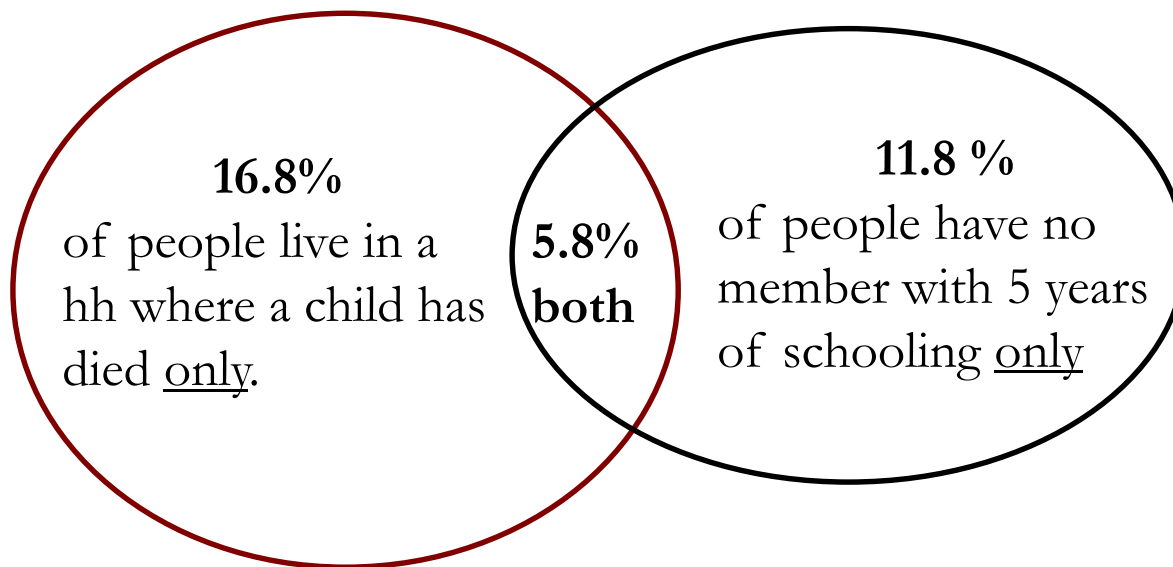
India NFHS data 2005-6 (sub-sample)

Raw headcount of child mortality

Raw headcount of schooling

22.6%

17.6%



Are they mostly the same people? **Less than one-third of the time.**

The Contingency Table (Cross-tab)

When we are analysing two dichotomous variables...

	Child mortality		
Safe water	Non deprived = 0	Deprived = 1	Total
Non Deprived = 0	4	2	6
Deprived = 1	1	3	4
Total	5	5	10

Headcount ratios: Safe water=50%, Child mortality= 40%

Cross-tabs are a basic way to view the joint distribution

The Contingency Table

Formally:

Safe water (I)	Child mortality (J)		Total
	Non deprived = 0	Deprived = 1	
Non deprived = 0	n_{00}	n_{01}	n_{0+}
Deprived = 1	n_{10}	n_{11}	n_{1+}
Total	n_{+0}	n_{+1}	n

n_{ij} are the cell count frequencies

n_{i+} , n_{+j} are the row, and column **marginal** totals

$$n = \sum_{i=1}^I \sum_{j=1}^J n_{ij}$$

The Contingency Table

The contingency table gives information :

A) Joint distribution

Matches – two types

n_{00} number (percentage) of people who are not deprived

n_{11} number (percentage) of people who are deprived in both indicators

Mismatches – two types

n_{01} , n_{10} number (percentage) of people who are not deprived in one indicator but deprived in the other

B) Marginal distributions: headcount ratios n_{1+} , n_{+1}

Traditional Measures of Association

Association (**affinity**) between two (or more) nominal (dichotomous) variables refers to a “**coefficient**” that measures the **strength** and **direction**(sign) of the relationship between the two variables.

Most coefficients of association define **absence** of **association** (“null” relationship) as **independence**.

- This is tested through the χ^2 statistic.

Correlation

Now let's correlate the 0-1 deprivations. What happens?

The correlation is based on all of the elements of the cross-tab.

the raw headcount of each variable

the 'match' between deprivations

the 'match' between non-deprivations

the mismatches

Correlation

For 0-1 variables, the correlation coefficient is the same as the Cramer's V measure.

Cramer's V is the most popular measure of association between two nominal variables because of its norming range

In the 2x2 case, V ranges from 0 to ± 1 , and take the extreme values under (statistical) independence and “complete association”.

$$V = \frac{n_{00}n_{11} - n_{01}n_{10}}{(n_{0+}n_{1+}n_{+0}n_{+1})^{1/2}}, \in [-1, 1]$$

Meaning and interpretability of Correlation Coefficients / V

V^2 is the mean square canonical correlation between two variables.

2x2 correlation coefficients/ V could be viewed as the **percentage** of the **maximum possible variation** between two variables.

Cramer's V

V uses “**entire** cross-tab”

$$V = \frac{\overbrace{n_{00}n_{11}}^{\text{matches}} - \overbrace{n_{01}n_{10}}^{\text{mismatches}}}{\underbrace{(n_{0+}n_{1+}n_{+0}n_{+1})}_{\text{marginal distributions}}^{1/2}}, \in [-1,1]$$

Association is affected by:

- Extent to which deprivations between variables match (key)
- Values of the headcount ratios and their difference

Dilutes insights for redundancy.

Measure of Redundancy R^0

If two deprivation/poverty indicators are not independent, and if at least one of the marginal distributions n_{1+} , n_{+1} is different from zero P is defined as:

$$R^0 = \frac{n_{11}}{\min[n_{1+}, n_{+1}]} \in [0,1]$$

Sources of information used by R^0 :

n_{11} number of people who are deprived in both indicators \rightarrow **Joint**

n_{1+} , n_{+1} headcount ratios \rightarrow **Marginals**

Redundancy: reflects the strength of the matches,
but not the direction

Measure of Redundancy R^0

Meaning

Counts the number of observations which have the same status (both deprived/both poor) in both variables, adjusted by the “level” of deprivation (poverty for censored headcount)

Strength of the relationship is defined as the **proportion** of “**poverty matches**” in the **lowest level** of poverty

This measure is sensitive to some distributional changes.

Interpreting R^0

If $R^0 = 90\%$, it shows that 90% of the people who are deprived in the indicator with the lowest headcount are also deprived in the other indicator.

This is a high association!

- That is not bad or good on its own – we need to think...
- Do we need both indicators or is one redundant?
- How do we justify keeping the two?
 - E.g. are they of independent value normatively or for monitoring purposes?

Example - Mozambique DHS

Case I

School attendance (J)

Years school. (I)	Non deprived= 0	Deprived= 1	Total
Non deprived=0	47.15%	14.53%	61.68%
Deprived= 1	22.05%	16.27%	38.32%
Total	69.20%	30.80%	100%

$$V = \frac{n_{00}n_{11} - n_{01}n_{10}}{[n_{0+}n_{1+}n_{+0}n_{+1}]^{1/2}} = 0.199$$

$$R^0 = \frac{n_{11}}{\min[n_{1+}, n_{+1}]} = 0.528$$

Example – Mozambique & Bangladesh

<u>Panel I: Mozambique</u>		Attendance		
		Non deprived= 0	Deprived=1	Total
Schooling	Non deprived=0	47.15%	14.52%	61.68%
	Deprived= 1	22.05%	16.27%	38.32%
	Total	69.20%	30.80%	100.00%

<u>Panel II: Bangladesh</u>		Attendance		
		Non deprived= 0	Deprived=1	Total
Schooling	Non deprived=0	71.07%	9.43%	80.49%
	Deprived= 1	13.76%	5.75%	19.51%
	Total	84.82%	15.18%	100.00%

Example - Bangladesh DHS

Case I

School attendance (J)

Years school. (I)	Non deprived= 0	Deprived= 1	Total
Non deprived=0	71.06%	9.43%	80.49%
Deprived= 1	13.76%	5.75%	19.51%
Total	84.82%	15.18%	100%

$$V = \frac{n_{00}n_{11} - n_{01}n_{10}}{[n_{0+}n_{1+}n_{+0}n_{+1}]^{1/2}} = 0.196 \quad R^0 = \frac{n_{11}}{\min[n_{1+}, n_{+1}]} = 0.379$$

Two different countries with **completely different** patterns of deprivation show the **same association** coefficient **V**, but **different** measures of redundancy **R⁰**

Mozambique: Cramer's V vs. R⁰

Correlation Matrix

	Schooling	Attendance	Safe water
Attendance	0.199	1.000	
Safe water	0.330	0.188	1.000
Cooking fuel	0.139	0.111	0.201

Overlap/Redundancy Measure

	Schooling	Attendance	Safe water
Attendance	0.529		
Safe water	0.776	0.708	
Cooking fuel	0.999	0.997	0.999

Mozambique: Cramer's V vs. R⁰

Correlation Matrix

	Schooling	Attendance	Safe water
Attendance	0.199	1.000	
Safe water	0.330	0.188	1.000
Cooking fuel	0.139	0.111	0.201

Overlap/Redundancy

	Schooling	Attendance	Safe water
Attendance	0.329	1.000	
Safe water	0.776	0.708	1.000
Cooking fuel	0.999	0.997	0.999

Highest redundancy.
May suggest that cooking fuel is redundant, unless it is retained for other normative reasons.

Association and Redundancy

Divergence reflects the different components of the cross-tab that they draw upon.

Measure of redundancy or overlap provides clear and precise information that should be considered when evaluating indicator redundancy

Exercise

Analyse the relationships between your indicators:

- a) Compute the cross-tabs
- b) Compute Cramer's V
- c) Compute the Measure of Redundancy R^0
- d) Compare the measures (V - R^0) and interpret your results