More than cold homes: Energy poverty as a moderator of the poverty–health nexus in Poland

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Motivation

1. **Poverty and health**

   Individuals with lower incomes are more likely to experience health problems, as confirmed by international and European studies.

2. **Energy poverty as a growing societal issue**

   An increasing number of households are unable to maintain adequate thermal conditions, which may affect both physical and mental health – although these relationships are still insufficiently understood.

3. **Widening health inequalities across the population**

   Poland is among the EU countries where income-related and socio-economic health disparities persist.

4. **Implications for social and health policy**

   Identifying the relationship between poverty and health can help design more precise and effective public interventions – particularly in addressing energy poverty.

The role of energy poverty

1. **Thermal discomfort → risk of physical illness**
   Cold or overheated homes increase the risk of respiratory and cardiovascular diseases.
2. **Low-quality fuels → indoor air pollution**
   Burning poor-quality fuels leads to greater exposure to harmful substances, especially among vulnerable individuals.
3. **Difficulty paying utility bills → financial stress**
   Ongoing problems with covering energy costs create economic pressure, which can lead to chronic stress and deteriorating mental health.
4. **Giving up heating/cooling → social isolation**
   Lack of comfort at home discourages activity and social interaction, negatively affecting well-being and potentially leading to loneliness.
5. **Energy poverty as a factor exacerbating household hardships**
   Combined with limited income, it can increase the risk of negative health outcomes.

Literature review: energy poverty, poverty and health

- **Geographical contexts:**
  - China (Q. Zhang et al., 2021; Z. Zhang et al., 2021; Li et al. 2022; Fan et al. 2025)
  - 50 developing countries (Banerjee et al., 2021)
  - Countries across Europe, Asia, North and South America, Africa, Australia (Churchill et al. 2020; Igawa and Managi, 2022; Liang et al. 2024; Buchner and Rehm 2025)
  - Pakistan (Batool et al., 2023); Peru (Clausen et al., 2024)
- **Concepts and outcomes:**
  - Energy poverty and children's well-being (Q. Zhang et al., 2021)
  - Energy poverty, health and education outcomes, life expectancy, infant mortality (Banerjee et al., 2021)
  - Multidimensional energy poverty, physical and mental health, depression (Jessel et al., 2019; Z. Zhang et al., 2021)
  - Energy poverty and income inequality (Igawa and Managi, 2022)
  - Energy poverty, income and health poverty, environmental poverty (Batool et al., 2023)
  - Multidimensional poverty and depression (Clausen et al., 2024)
- **Statistical methods / approaches:**
  - Regression, mediation tests, sensitivity analyses
  - Fixed-effects and threshold regressions
  - Three-level hierarchical models
  - Structural equation modelling (SEM)
  - Systematic literature review

Aim of the research

Main aim:

To examine the correlation between poverty and health, and to investigate how energy poverty may moderate this association.

Research questions:

1. What is the correlation between poverty and health?
2. Does energy poverty amplify this correlation?
3. Does this correlation differ across dwelling types?

Contribution

Conceptual

- Formally test how one form of deprivation changes the correlation between poverty and health (moderation).

Empirical

- First quantitative assessment of this moderating relationship in Poland (CEE context), a high-risk but under-researched setting.
- Use harmonised EU-SILC microdata, allowing future cross-country extensions.

Theoretical

- Empirically examine the correlation between poverty and health, consistent with theoretical expectations and international literature.

Methodological

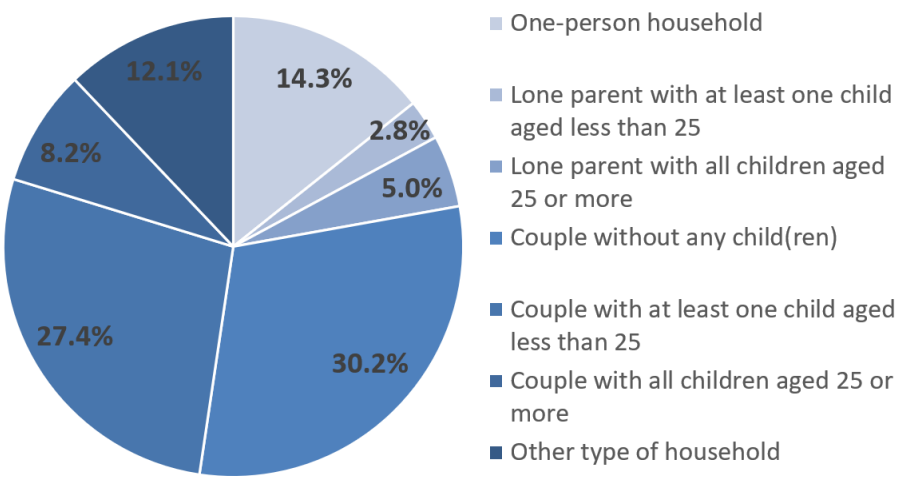
- Apply Covariance-Based Structural Equation Modelling (CB-SEM) to model multidimensional latent constructs and estimate moderation and group differences in one framework.

Data

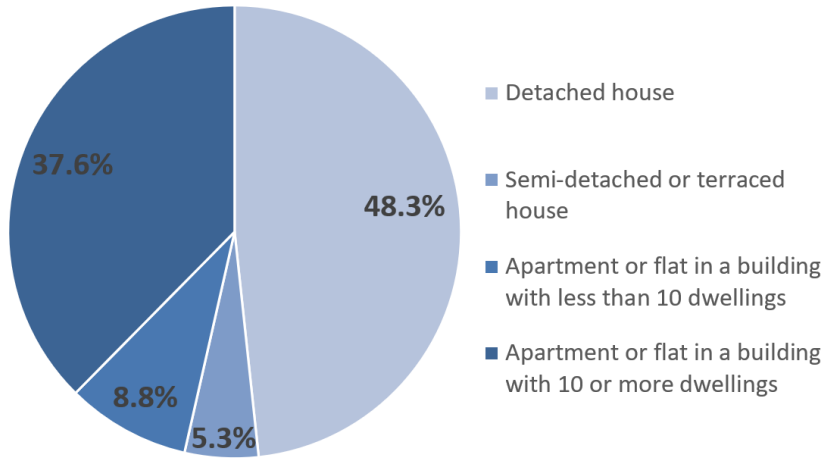
- Source: Eurostat, EU statistics on income and living conditions (EU-SILC)
- Country: Poland
- Year: 2023
- Files: Household data + Personal data
- Observations: 26,464

Composition of household and dwelling types

HOUSEHOLD TYPE



DWELLING TYPE



Latent variables

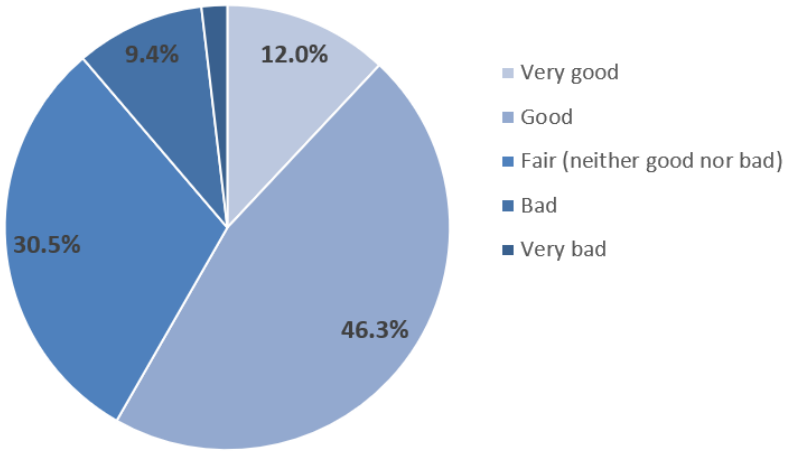
Latent construct	Observed variable	Description
Health	H_1	Self-perceived general health
	H_2	Suffer from any chronic [long-standing] illness or condition
	H_3	Limitation in activities because of health problems
Poverty	P_1	Ability to make ends meet
	P_2	Capacity to face unexpected financial expenses
	P_3	Financial burden of the total housing cost

Aggregate variable

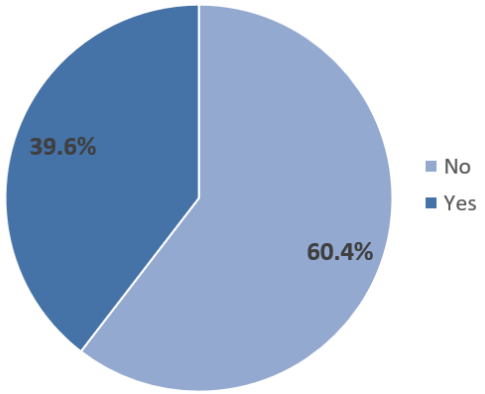
Latent construct	Observed variable	Description
Energy poverty	EP_1	Ability to keep home adequately warm
	EP_2	Arrears on utility bills

Health variables

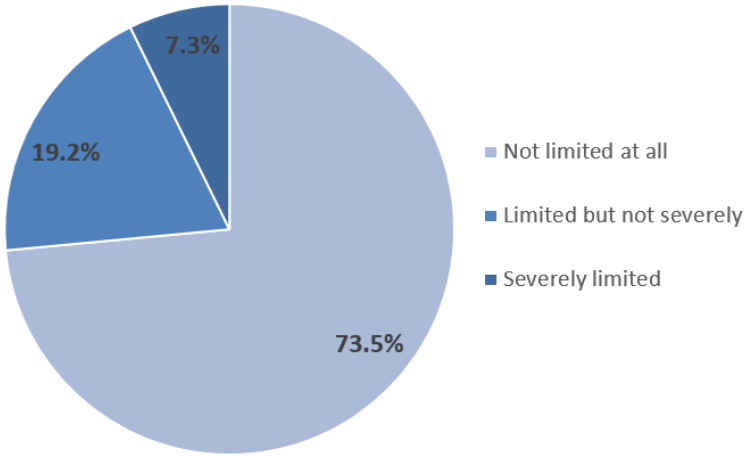
H_1: Self-perceived general health



H_2: Suffer from any chronic (long-standing) illness or condition

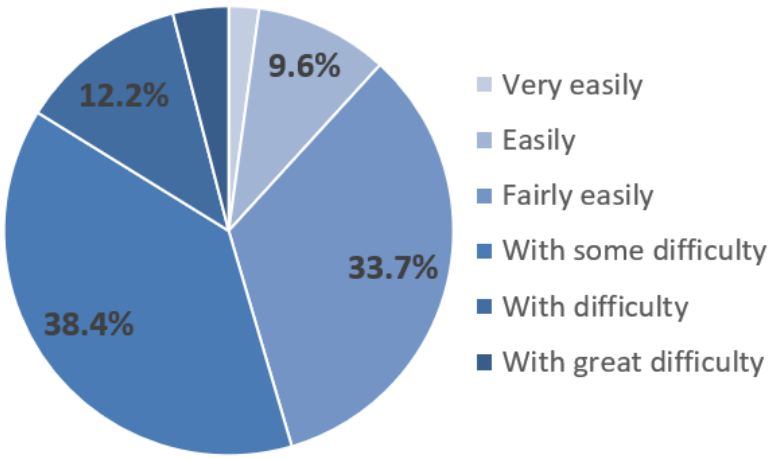


H_3: Limitation in activities because of health problems

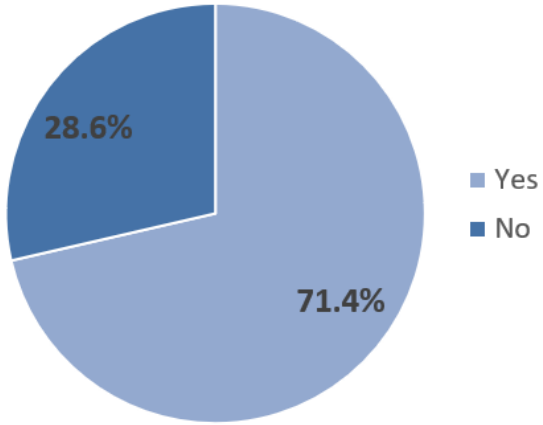


Poverty variables

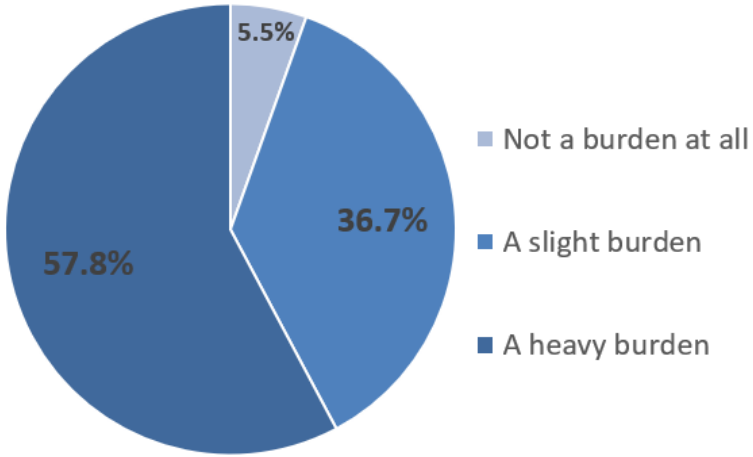
P_1: Ability to make ends meet



P_2: Capacity to face unexpected financial expenses

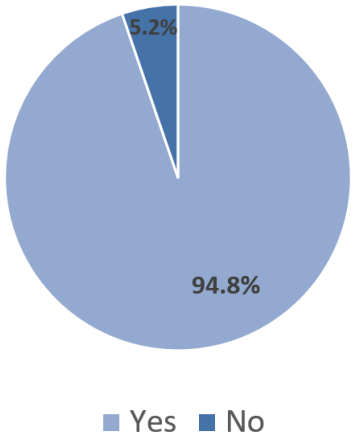


P_3: Financial burden of the total housing cost

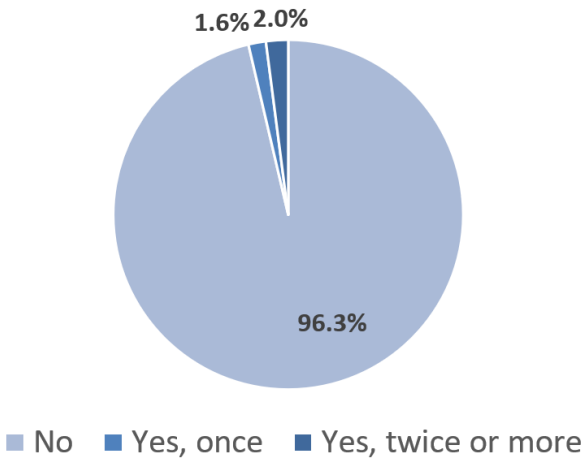


Energy poverty variables

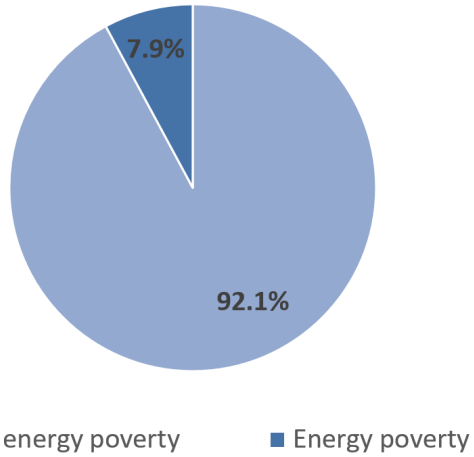
EP_1: Ability to keep home adequately warm



EP_2: Arrears on utility bills



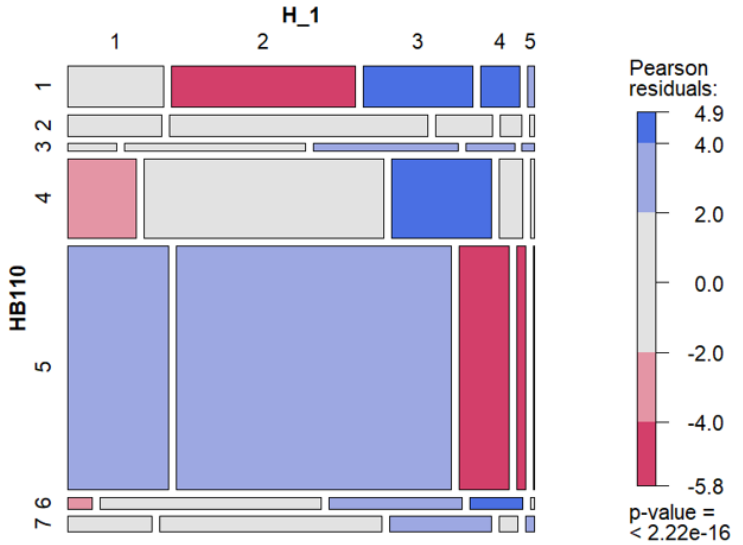
EP_final: Energy poverty

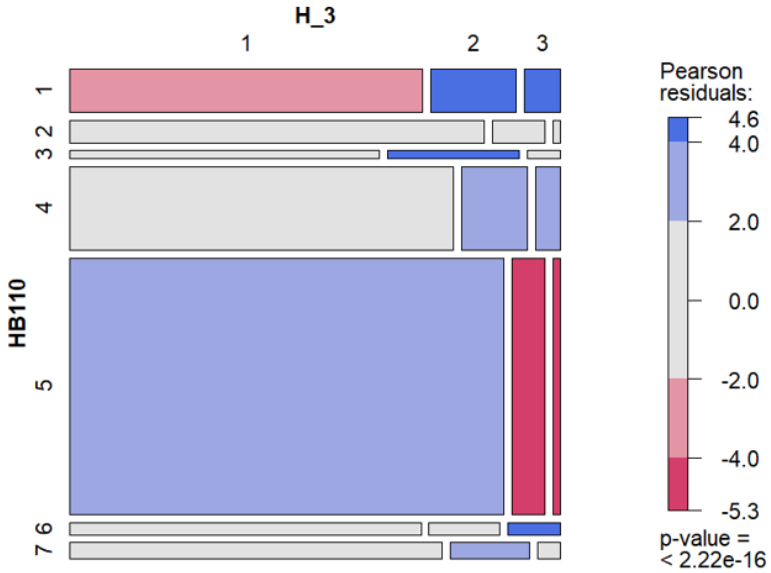


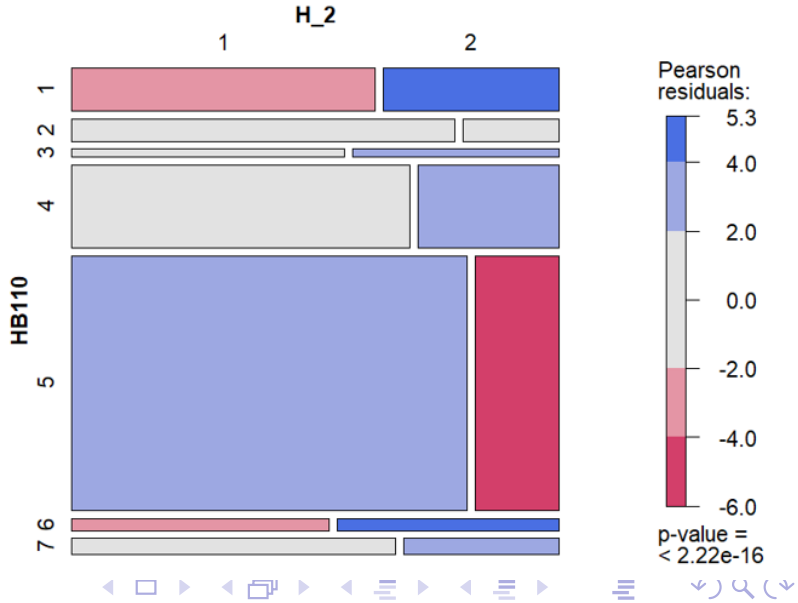
Mosaic plots for health (household type)

HB110:

1 – One-person household
2 – Lone parent with at least one child aged less than 25
3 – Lone parent with all children aged 25 or more
4 – Couple without any child(ren)
5 – Couple with at least one child aged less than 25
6 – Couple with all children aged 25 or more
7 – Other type of household



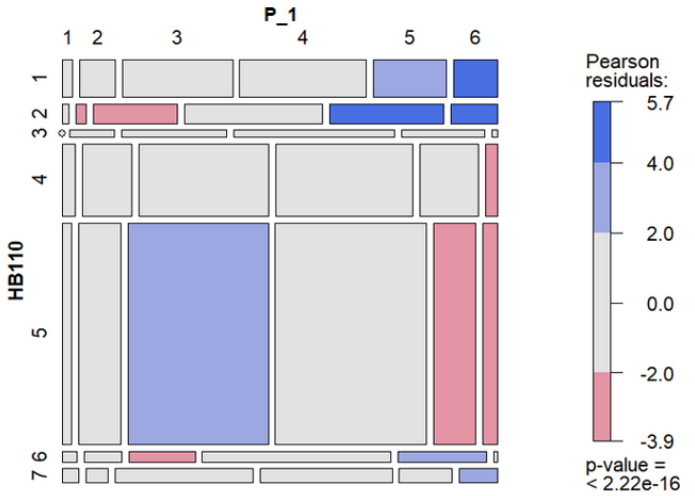


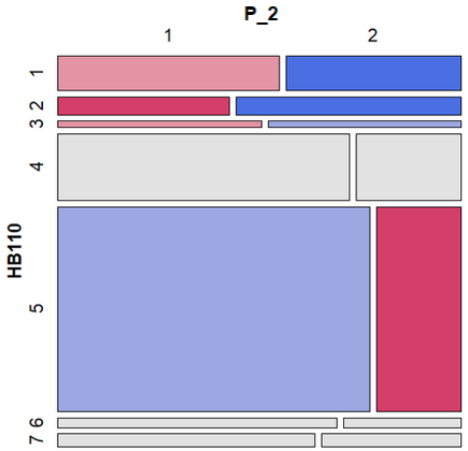


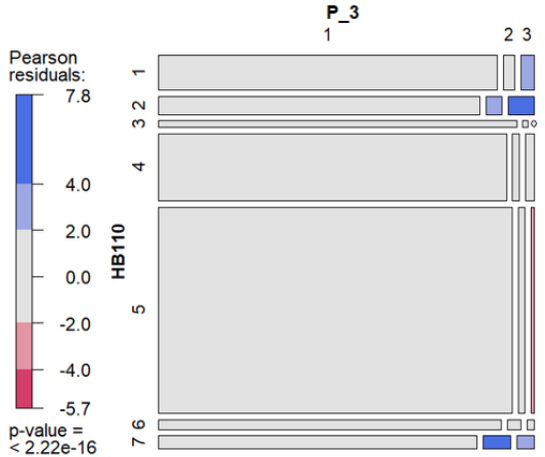
Mosaic plots for POV and EP (household type)

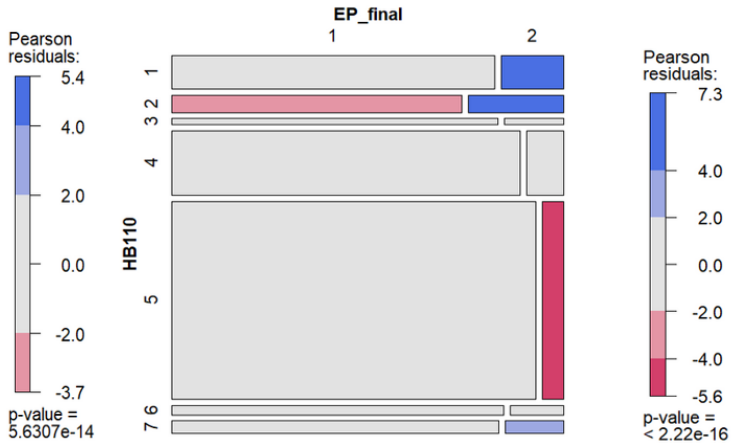
HB110:

1 – One-person household
2 – Lone parent with at least one child aged less than 25
3 – Lone parent with all children aged 25 or more
4 – Couple without any child(ren)
5 – Couple with at least one child aged less than 25
6 – Couple with all children aged 25 or more
7 – Other type of household

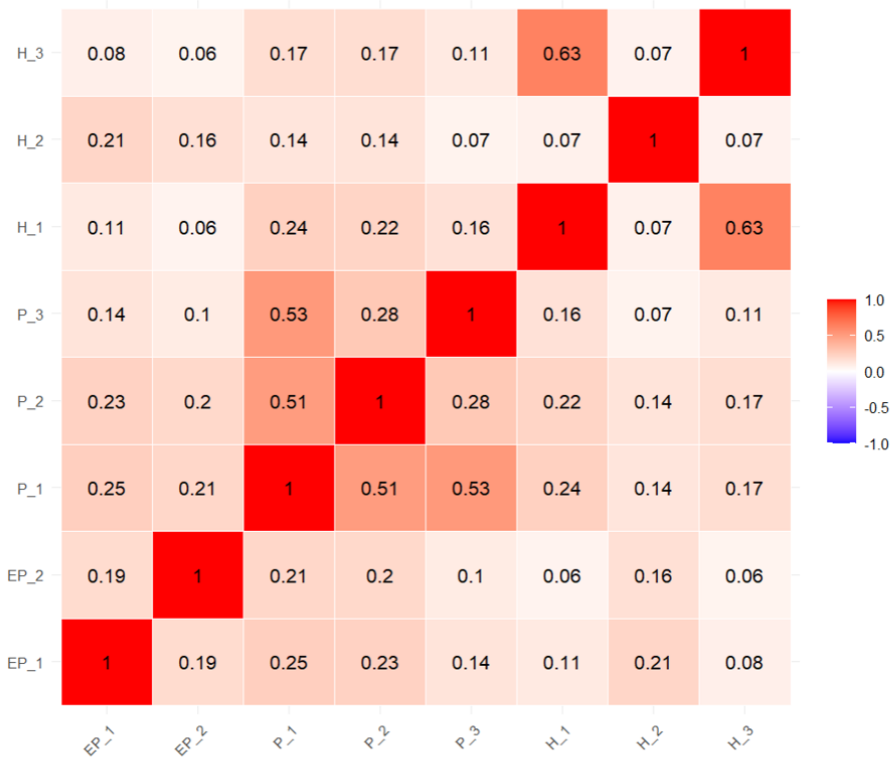


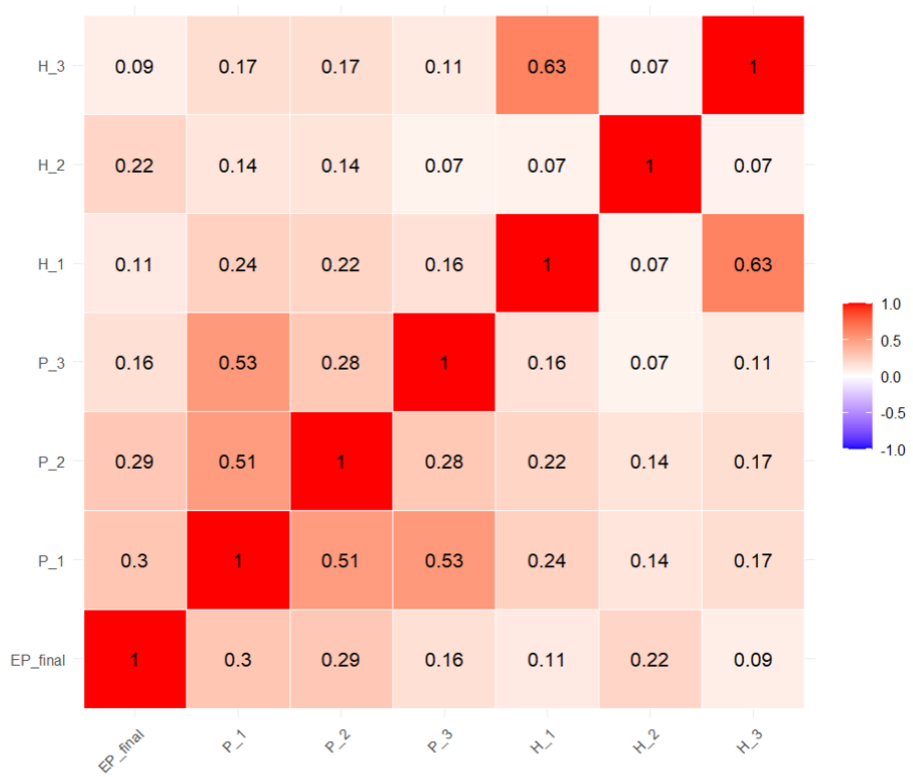






Correlation matrix





The latent construct of energy poverty based on EP_1 and EP_2 showed insufficient reliability and validity: Composite Reliability (CR) = 0.31 (threshold > 0.70), Cronbach's alpha = 0.31 (threshold > 0.60), and Average Variance Extracted (AVE) = 0.19 (threshold > 0.50).

Methodology: CFA and SEM

- **Confirmatory Factor Analysis (CFA)** tests whether observed variables represent underlying constructs.
- **Structural Equation Modelling (SEM / CB-SEM)** estimates relationships among latent and observed variables within a theoretical framework.
- SEM:
  - accounts for measurement error,
  - allows testing mediating and moderating effects,
  - requires a theoretically grounded model, sufficient sample size, multivariate normality, linearity and low multicollinearity.
- Since our data violate normality and include categorical variables, we use the **WLSMV** estimator, which is robust in such conditions.

Confirmatory factor analysis

Table 1. Factor loadings and reliability metrics for six observed variables

Construct	Item	Standard loadings*	CR	Cronbach-α	AVE
Poverty	P_1	0.927	0.818	0.662	0.668
	P_2	0.549			
	P_3	0.565			
Health	H_1	0.805			
	H_2	0.806	0.837	0.809	0.644
	H_3	0.794			

*All factor loadings are significant ($p < 0.001$) in the model; Standard loading – threshold > 0.30, CR – threshold > 0.70, Cronbach-alpha – threshold > 0.60, AVE – threshold > 0.50.

Table 2. Fit measurements for CFA Model

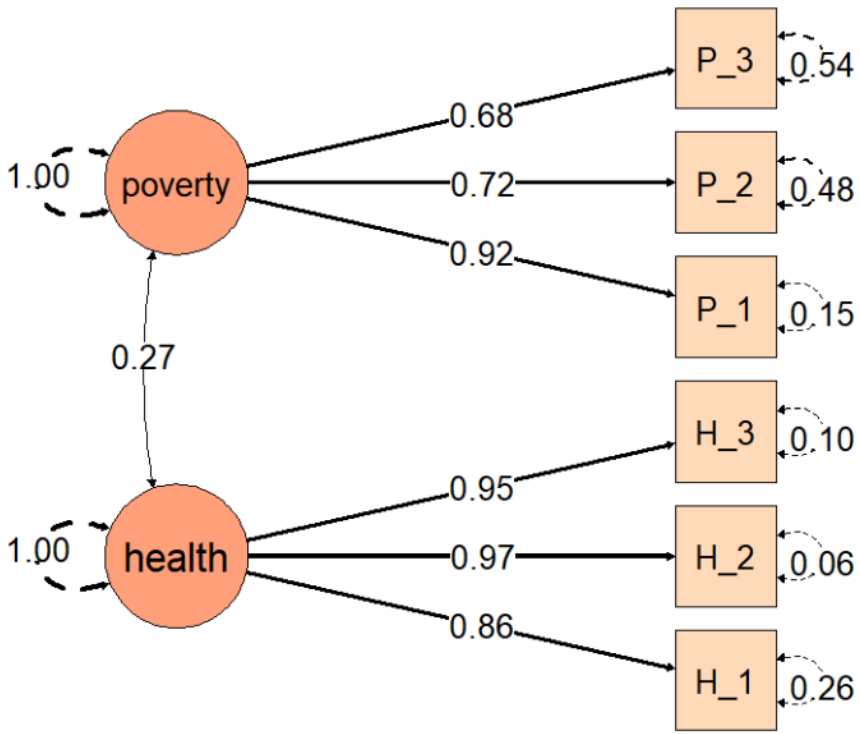
	Suggested values*	CFA Model
CFI	> 0.90	0.984
RMSEA	< 0.08	0.062
IFI	> 0.90	0.984
TLI	> 0.90	0.970
AGFI	> 0.90	0.973

*(Dash and Paul, 2021)

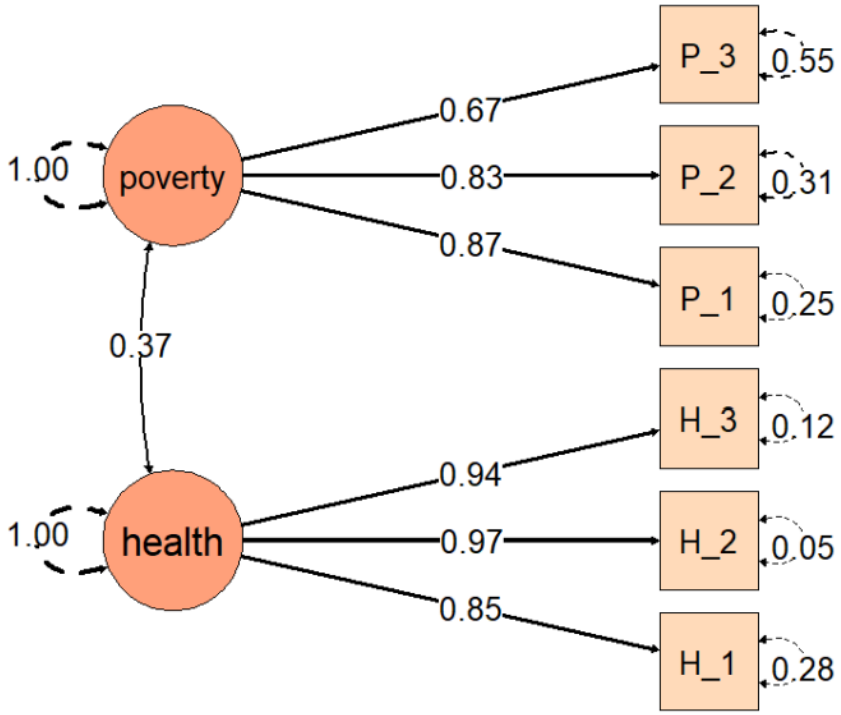
↓

Confirmation of a well-fitting measurement model through CFA.

Results – SEM model



a) Non-energy poor households



a) Energy poor households

Fit measurements for SEM model

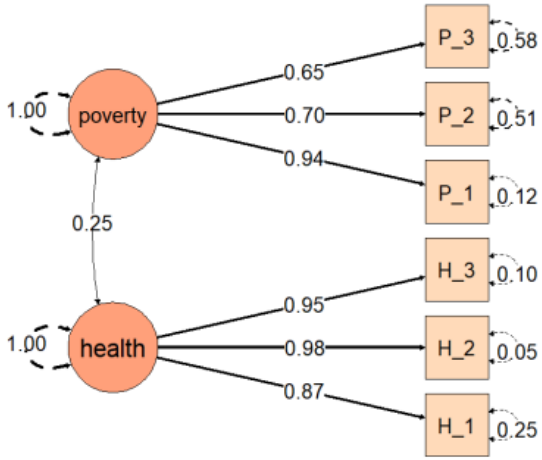
Table 3. Fit measurements for SEM Model

	Suggested values*	SEM Model
CFI	> 0.90	0.978
RMSEA	< 0.08	0.058
IFI	> 0.90	0.998
TLI	> 0.90	0.958
AGFI	> 0.90	0.996

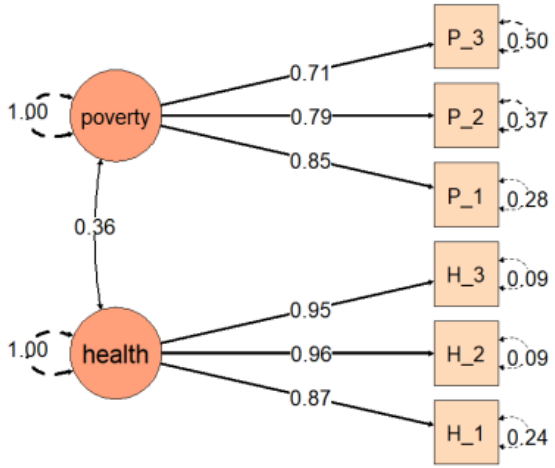
*(Dash and Paul, 2021)

All indexes are a good standard for adoption, thus indicating that the model is good.

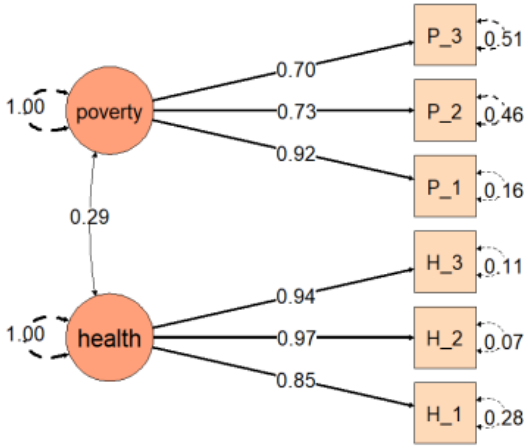
Correlation between poverty and health by dwelling type



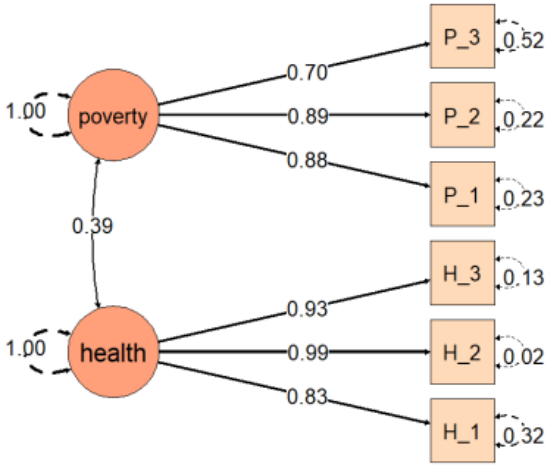
a) Non-energy poor households and detached, semi-detached, or terraced houses



b) Energy poor households and detached, semi-detached, or terraced houses



c) Non-energy poor households and apartments or flats



d) Energy poor households and apartments or flats

Conclusions

- Material deprivation is negatively associated with self-reported health in Polish households.
- Energy poverty strengthens this negative correlation – the difference between energy-poor and non-energy-poor groups is moderate but consistent.
- The poverty–health link is stronger among households living in flats/apartments than in detached or semi-detached houses.

Policy implications

- Policy interventions should adopt integrated, housing-sensitive approaches to energy poverty and health.
- Energy assistance and retrofit programmes (e.g. *Clean Air Programme*) should expand beyond rural, coal-heated homes to include low-income residents of older apartment blocks.
- Support for collective renovations, reduced administrative barriers and targeted financial aid are essential to address overlooked urban contexts.
- Energy poverty should be treated as a public health issue, not only a housing or energy concern.
- Stronger coordination between health, energy and social policy is needed to identify at-risk groups and design effective interventions.

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Thank you for your attention!