

# Constructing families using administrative registers

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## Abstract

*In the next census round in 2020–21, Estonia will conduct its first register-based census. In the register-based setting, households are formed of people who share a place of residence. The Estonian Population Register is lacking correct data on the residence of about 20% of people. The pilot census in 2016 revealed that relying on this data produces heavily biased statistics of households and families, e.g. share of lone parent families was 41% in the pilot census, but only 24% in 2011 census. This overestimation results from family members registered in different dwellings.*

*The key problem in reconstructing the families from the data is to detect partners if their registered home addresses do not coincide. To solve this problem, we collected additional information on ‘signs of partnership’ (SOPs): marriage, housing loans, mutual children, co-owning property and other administrative data that connects two persons and indicates potential partnership. Data on 17 SOPs from 9 registers was used to predict partnership status. The Estonian Social Survey and Estonian Labour Force Survey provided us data on actual partnership status.*

*A model based on logistic regression and stable marriage matching on 2018 SOP data was used to predict partnership. Predicted partnership was used as an input to construct register-based nuclear families of Comparative Survey of Household and Place of Residence respondents. The distributions of family characteristics improved substantially. Share of lone parents in the sample was 22% according to self-reported data and 24% by register data. In greater detail, however, the proportion of families of adult children is systematically overestimated – a result of particularly widespread mismatch between actual and registered place of residence among young adults.*

**Keywords:** Couples, families, place of residence, population register, register-based census

## 1. Introduction

The list of countries that perform register-based censuses will include five new countries in the 2020 census round: Spain, Turkey, Lithuania, Latvia and Estonia (UNECE, n.d.). Estonia has actively prepared for the first register-based census since 2010 (Matteus, 2013). The census topics are covered by registers and the unified identification system for people, addresses and businesses allows linking different sources easily (Tiit, 2015). The first Estonian pilot census in 2016 proved satisfactory in terms of quality for most of the census characteristics. However, in a report on this pilot census it is stated that the greatest problem with register-based census is the

difference between registered and actual places of residence. (Statistics Estonia, 2017)

According to the Population Register Act, it is compulsory for the residents to register their home address in the Population Register (PR) and keep that information up to date (Population Register Act, 2000). In 2015, the Estonian Labour Force Survey included questions about registering the place of residence in PR. Among 15–74-year old respondents, only 88% were registered in their actual home. The main reason for not registering the actual place of residence was that it was considered unnecessary. Many also stated that they lived in the current dwelling only temporarily or there were some local benefits involved (place in kindergarten or school, optimising land tax *etc.*) (Äär, 2017). According to the Comparative Survey of Household and Place of Residence (CSHPR), 80% of people had the correct address in PR in 2018.

The ignorance of having a correct place of residence in PR also applies to emigrants. It has been estimated that in 2016, 3% of people in PR were actually unregistered emigrants (Meres, 2017). Since PR is over-covered, it cannot directly be used as a population frame for census.

The *residency index* is a methodology Statistics Estonia developed to determine the actual population. It is based on the idea that actual residents of Estonia show up in various registers more often than non-residents. Each activity in the register – e.g. going to school, working, visiting doctor – is a binary variable called ‘sign of life’ (SOL). The residency index for each individual at a given moment is a weighted sum of his/her SOLs from the previous year. Weights depend on each SOL’s capacity to discriminate residents from non-residents. (Tiit and Maasing, 2016; Maasing, Tiit and Vähi, 2017)

The residency index has been used to calculate the population size since 2016 and migration flows since 2015. To estimate the population size for 1 January 2019, 33 SOLs from 17 registers were used.

Poor registration of place of residence data also distorts the statistics on families and households. In the PC2016, distribution of family nuclei by type deviates heavily from the 2011 census. In the 2011 census, 24% of nuclear families were lone partner families. With register-based method, lone parent families constituted 41% of all family nuclei. Accordingly, proportion of married and consensual union couples showed a drop from 76% in 2011 census to 59% in PC2016 (Statistics Estonia, 2017). Although

changes in society over 4 years and in household definition also contribute, the over-estimation of lone parents is mostly explained by family members registering in different dwellings (Tiit, Visk and Levenko, 2018).

Bringing together the family members who are registered at different addresses is a complex, yet not unsolvable task. PR covers links between children and their parents and contains information of married couples. Other registers offer hints that either increase or decrease the probability of partnership of potential partners, e.g. co-owning a property or paying alimony. Statistics Estonia is developing a methodology called 'partnership index' that uses these 'signs of partnership' (SOPs) to find actual couples. In essence, it is analogous to residency index as it uses additional administrative sources to correct the biases induced by poor quality of place of residence data in PR. In this paper, we give an overview of the partnership index and test its impact on family composition on survey data.

## **2. The partnership index**

The earlier versions of partnership index are introduced in-depth in previous publications (Tiit, Visk and Levenko, 2018; Visk, 2019).

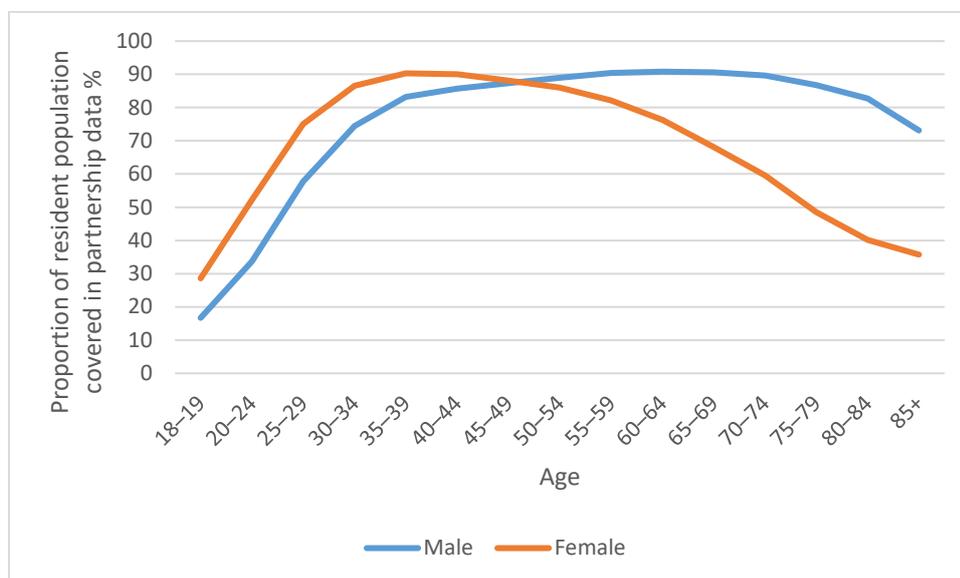
The partnership data covers all couples that share at least one SOP. To narrow down the task of finding partners, the data is restricted to opposite-sex couples. Close relatives are excluded and only adult population ( $\geq 18$  years of age) is considered. One person may have SOPs with multiple people. We call the couples in the partnership data 'quasi-couples'. The goal of partnership index is to find actual partners among the quasi-couples.

In 2018, data on 17 SOPs was extracted from 10 registers (see Table 1). In addition, true partnership status was obtained from the Estonian Labour Force Survey and Estonian Social Survey 2017. Altogether, there were 677,347 quasi-couples of non-relatives consisting of 413,045 men and 440,119 women. On average, women had 1.5 quasi-partners and men had 1.6.

According to the residency index, 93% of people were Estonian residents. The partnership data included 75% of adult resident population. The population coverage in partnership data varies by sex and age (Figure 1). The proportion of people with SOPs is low in younger age groups and grows with age as people marry, buy homes,

have children etc. In older age, the proportion of people of SOPs decreases. Both rise and decline in SOPs occur earlier for women.

**Figure 1. Population coverage of partnership data by sex and age group**



About 17% of quasi-couples, or 117,922, contained at least one register-based lone parent of an adolescent child (<18 years old).

Table 1 gives an overview of SOPs in 2018 partnership data. Partnership status was known for 24,453 quasi-couples, one third of them were actual partners. The most prevalent SOPs (present in over 200,000 quasi-couples) were sharing a vehicle (e.g. one quasi-partner is a user of a car that other quasi-partner owns), sharing the place of residence in PR and marriage. The strongest predictor of partnership was transferring unused income tax deduction to spouse – an option for married couples to optimize taxes. Almost all (94%) quasi-couples with this SOP were actual couples. Out of married couples, 90% were actual partners. Other strong indicators of partnership were mutual housing loan (85% of quasi-couples were partners), two people co-owning real estate (84%), taking paternity leave and sharing parental benefit after childbirth (84% and 85%, respectively). Most of other SOPs were weaker but still positive indicators of partnership. The only exceptions that had lower than average share of partners were paying alimony (10% were partners) and divorce (4%; 25%, if data on divorce was contradictory).

**Table 1. List of SOPs with data sources, prevalence and probability of partnership (1 January 2018)**

<b>Sign of partnership</b>	<b>Source</b>	<b>N</b>	<b>Probability of partnership %</b>
Marriage	Population Register	202,736	90.1
Half-marriage*	Population Register	1,624	64.9
Declaration of income	Register of Taxable Persons	30,602	94.0
Housing loan	Register of Taxable Persons	45,276	85.1
Place of residence	Population Register	275,825	59.5
Real estate, up to 6 co-owners	Land Register	96,623	65.7
Real estate, 2 co-owners	Land Register	79,573	83.8
Children, incl. stillbirths	Estonian Medical Birth Registry 2012–2017, Population Register	167,993	65.4
Paternity leave	Social Security Information System	34,676	84.3
Care leave (caring for each other or a mutual third person, typically a child)	Health Insurance Information System	15,864	77.0
Shared parental benefit	Social Security Information System	7,350	85.2
Sharing a vehicle	Estonian Traffic Register	299,947	39.9
Buying prescription drug for quasi-partner	Estonian Medical Prescription Centre 2015–2017	191,029	57.0
Subsistence benefit	Social Services and Benefits Registry 2015–2017	3,625	75.6
Divorce	Population Register	88,303	4.4
Half-divorce*	Population Register	708	25.0
Alimony	e-File	3,507	9.6
Partnership status known from survey data	Estonian Labour Force Survey 2017, Estonian Social Survey 2017	24,453	32.1

\* Half-marriage and half-divorce represent inconsistent cases of PR, e.g. person is a husband for multiple wives.

To classify quasi-couples into partners and non-partners, multiple logistic regression was used (Table 2). Covariates included SOPs and additional time-related variables.

- *Penalty for improbable age differences.* In general, spouses have similar ages. Large gap in ages suggests that partnership is unlikely. Penalty is applied if man is older than woman by more than 20 years or woman is older than man by more than 15 years. Only 0.5% of the survey couples exceeded these limits.
- *Time since last event.* Some SOPs convey information on time: children are born, prescription drugs are bought and court decision on alimony are made on known dates. It is natural to assume that recent events are more relevant when deciding on partnership status. For example, in survey data, among parents with youngest child aged two, 88% were partners, whereas only 50% of parents of 12-year-olds were still together. Events that increase probability of partnership (e.g. marriage, paternity leave) and decrease it (divorce, alimony) are handled separately. In the model, geometrical relationship  $0.9^Y$  is used, where  $Y$  stands for time between most recent event and census moment.

**Table 2. Coefficients of logistical regression model for partnership**

Covariate	Regression coefficient (log-odds) <sup>§</sup>	(95% confidence interval)
Intercept	-3.90***	(-3.99; -3.80)
Marriage	3.10***	(2.98; 3.22)
Half-marriage	2.06***	(1.12; 3.03)
Declaration of income	-0.44*	(-0.81; -0.05)
Housing loan	0.39**	(0.10; 0.68)
Subsistence benefit	1.10***	(0.55; 1.67)
Real estate, 2 co-owners	0.96***	(0.74; 1.18)
Place of residence	2.10***	(2.00; 2.20)
Number of children, incl. stillbirths	1.05***	(0.96; 1.14)
Divorce	-0.52**	(-0.88; -0.18)
Alimony	-1.00*	(-1.99; -0.10)
Paternity leave	0.67***	(0.40; 0.95)

Covariate	Regression coefficient (log-odds) <sup>§</sup>	(95% confidence interval)
Buying prescription drug for quasi-partner	1.12***	(0.96; 1.28)
Sharing a vehicle	0.81***	(0.67; 0.95)
Time since last positive event	1.07***	(0.86; 1.28)
Time since last negative event	-0.94**	(-1.59; -0.28)
Man at least 20 years older †	-14.9***	(-17.86; -12.45)
Woman at least 15 years older ‡	-37.36***	(-48.5; -28.83)

§ P-values are marked by asterisks

\* –  $p < 0.05$ , \*\* –  $p < 0.01$ , \*\*\* –  $p < 0.001$

† Let  $\Delta = \text{age}_{\text{man}} - \text{age}_{\text{woman}}$ . The value of covariate is given by  $1 - 0.95^{\Delta-20}$  for  $\Delta > 20$  and 0 for  $\Delta \leq 20$ .

‡ The value of covariate is given by  $1 - 0.97^{-\Delta-15}$  for  $\Delta < -15$  and 0 for  $\Delta \geq -15$ .

Quasi-couple data includes only couples that share a SOP and a small fraction of survey couples that did not have any SOPs (3%). These are only quasi-couples in the data with no SOPs and they have 100% probability of being partners. This blurs the effect of SOPs on partnership. To better distinguish partners from non-partners, dummy negative records were introduced to fit the model. Each resident man was assigned a random resident woman and it was assumed that all resulting quasi-couples were non-partners.

Only variables that were statistically significant in full model with all SOPs and time-related variables were included in the final model. The strongest SOP was marriage – being married increases the *odds* of partnership by  $e^{3.1} = 22$  times. Declaration of income is a SOP that applies only to married couples. When adjusted to other variables in the model, transferring unused tax deduction to spouse weakens the effect of marriage. Half-marriage and sharing the place of residence in PR are also strong predictors of partnership. Buying prescription drugs for the partner, receiving subsistence benefit in the same household, having mutual children, co-owning property, sharing a vehicle, taking paternity leave and having joint housing loan also increase the odds of partnership. As expected, alimony, divorce and large age

differences lower the probability of partnership. Recent positive events raise odds of partnership while recent negative events reduce it.

The partnership index is the prediction of the logistic regression model. It is natural to assign positive partnership status to quasi-couples with index exceeding a certain threshold. However, one person may have high index value with multiple possible partners. Also, the best choice of someone may not prefer him or her. Consider a situation with three hypothetical quasi-couples  $AB = \{\text{Adam, Betty}\}$ ,  $AD = \{\text{Adam, Daisy}\}$  and  $CB = \{\text{Colin, Betty}\}$ . All couples have higher index value than the given threshold, say 0. Let partnership index values for quasi-couples be  $I_{AB} = 4$ ,  $I_{AD} = 3$ ,  $I_{CB} = 6$ . Although all couples have high index value, it is not feasible to assign two partners for Betty and Adam. Selecting a partner with *highest* index value may also leave room for ambiguity. In our example, Adam has the highest index value with Betty, but Betty has highest index value with Colin.

To solve conflicts and assign each person at most one partner, a graph-based solution has been proposed (Visk, 2019). Each person may be viewed as a vertex of a graph. Edges are drawn between people who share a SOP, i.e. quasi-couples. Gale-Shapley algorithm is used to achieve stable matching between men and women, that is '*there does not exist any match (A, B) by which both A and B would be individually better off than they are with the element to which they are currently matched*' (Gale and Shapley, 1962; Stable marriage problem, 2018). In other words, stable matching does not contain 'unstable pairs', where man and woman are not matched but would prefer each other (over their matched partner). Preferences are given by partnership index.

Finally, the threshold is set on a level that produces the same proportion of partners as in original data. Only quasi-couples from stable matching that exceeded the threshold were classified as partners. The list of model-predicted couples serves as an input in family construction.

### **3. Comparative Survey of Household and Place of Residence**

Comparative Survey of Household and Place of Residence (CSHPR) was conducted in 2018 by Statistics Estonia to

- 1) provide external validation for indexes in population statistics,

- 2) compare data collection methods (CAPI vs. CAWI and CAPI),
- 3) check e-mail access to people without place of residence in PR.

In this paper, we discuss only the first part of this survey that allows estimating the validity of the partnership index in register-based family formation.

The target population consisted of conventional dwellings and occupied non-residential buildings as at 1 January 2018. The sampling frame was combined from the Address Data System, Estonian Register of Buildings and PR. The list of addresses was stratified by size and type of administrative/settlement units into six strata:

- 1) Tallinn (the capital city),
- 2) county centres with more than 8000 inhabitants, and Keila and Maardu towns,
- 3) larger towns from Ida-Viru county (mainly Russian-speaking population),
- 4) other small towns,
- 5) seven municipalities surrounding Tallinn (suburban area),
- 6) other rural districts.

In the strata 1–3 and 5, addresses were sampled systematically. In strata 4 and 6, two-stage sampling was employed. In the first stage, clusters (towns/localities) were sampled systematically proportional to size. Among the selected clusters, addresses were sampled systematically. In total, the sample consisted of 7519 dwellings.

The survey was conducted from May to October 2018. Computer-assisted personal interviews were used for data collection. Altogether, data was collected on 5256 households in 5052 dwellings. The response rate, after correcting for sample frame errors – 515 missing dwellings and dwellings used for business – was 86% (939 unoccupied dwellings were considered as responses, because one goal of the survey was to determine the share of such dwellings). Out of 11,165 inhabitants, 10,824 were permanent residents and will be included in the following analysis.

On 1 January 2018, 8589 respondents – 3765 men and 4824 women – were at least 18 years old. Majority of them appeared in at least one quasi-couple (83% of men, 73% of women). CSHPR data included 2421 married and consensual union couples, 93% of them had at least one SOP. The partnership index classified 84% of CSHPR couples

correctly as partners. Another 9% had SOPs, but not enough to conclude partnership. The remaining 7% had no SOPs.

The sensitivity of finding actual couples varied by age. Only 63% of CSHPR couples with women under 30 were discovered by partnership index. In the older age groups, the sensitivity was higher: 87% for couples with woman aged 30–59 and 91% for older couples (women 60+).

The CSHPR respondents appeared in 7971 quasi-couples. Among them, 5432 were classified as non-partners, this decision was correct for 5213 (96%) of them. The negative predictive value was high in all ages.

In the subsequent analysis of family characteristics, we use different datasets to form dwelling-based households of CSHPR respondents:

- 1) CSHPR data;
- 2) PR data;
- 3) PR data, data on partnership is calculated with partnership index.

Although CSHPR allows the traditional housekeeping concept to define households, we prefer household-dwelling concept that is more relevant for comparison with register-based methods. The households are divided into family nuclei as defined in regulations (Commission Implementing Regulation (EU) 2017/543, 2017), *‘two or more persons who belong to the same household and who are related as husband and wife, as partners in a registered partnership, as partners in a consensual union, or as parent and child./.../ A son or daughter who lives with a spouse, with a registered partner, with a partner in a consensual union, or with one or more own children, is not considered to be a child.’*

When constructing register-based households of CSHPR respondents, some people outside the survey will also be involved. For example, if CSHPR respondent Alice is registered at the same address with Bob who was not in the sample, Bob will be a member of Alice's register-based household. In the analysis, only CSHPR respondents

are included. If not stated differently, the given distributions are based on unweighted data and therefore differ from population estimates (albeit slightly).

There were 3051 nuclear families in CSHPR. With register-based approaches, we consider families including *at least one* CSHPR respondent. Accordingly, the number of affected families is larger – 3500 with PR data alone and 3644 when partnership index data is added.

**Family nucleus types** obtained by different methods are compared in Table 3. In CSHPR, 22% of families were lone parent families. Similarly to 2016 pilot census, using only PR data inflates the share of lone parent families (to 40%). When applying the partnership index, the proportion of lone parent families falls to 24% – a result very close to CSHPR and a considerable improvement compared to using PR alone.

Across all types of families, we observe overestimation of families with adult children with register-based methods. At the same time, both married and consensual union couples without children are fewer than expected.

**Table 3. Type of family nucleus**

Type of family nucleus %		Basis for household formation		
		Dwelling-based from CSHPR	PR only	PR + partnership index
		N = 3051	N = 3500	N = 3644
<b>Families with couples</b>		<b>78.4</b>	<b>60.5</b>	<b>75.9</b>
<b>Married couple families</b>		<b>52.2</b>	<b>42.1</b>	<b>53.0</b>
	Without resident children	26.9	17.0	21.7
	With at least one resident child under 25	21.2	16.5	22.6
	Youngest resident son/daughter 25 or older	4.1	8.5	8.8
<b>Consensual union couple families</b>		<b>26.2</b>	<b>18.4</b>	<b>22.8</b>
	Without resident children	11.6	6.0	6.9
	With at least one resident child under 25	13.4	10.0	14.1

Type of family nucleus %		Basis for household formation		
		Dwelling-based from CSHPR	PR only	PR + partnership index
		N = 3051	N = 3500	N = 3644
	Youngest resident son/daughter 25 or older	1.1	2.5	1.9
<b>Lone parent families</b>		<b>21.6</b>	<b>39.5</b>	<b>24.1</b>
<b>Lone father families</b>		<b>2.6</b>	<b>6.6</b>	<b>3.4</b>
	With at least one resident child under 25	1.7	4.1	1.7
	Youngest resident son/daughter 25 or older	1.0	2.5	1.7
<b>Lone mother families</b>		<b>19.0</b>	<b>32.9</b>	<b>20.7</b>
	With at least one resident child under 25	12.1	20.4	11.3
	Youngest resident son/daughter 25 or older	6.9	12.5	9.4
<b>Total</b>		<b>100</b>	<b>100</b>	<b>100</b>

The distribution of the **size of family nucleus** is given in Table 4. Both register-based methods show larger families. The smallest possible number of family members is two – single person is not considered a family. With register-based methods, the share of two-person families is significantly lower (48% with PR, 45% with partnership index) than in CSHPR (55%). This is directly related to underestimating the couples with no resident children – all of these families have two members.

**Table 4. Size of family nucleus**

Size of family nucleus %	Basis of household formation		
	Dwelling-based from CSHPR	PR only	PR + partnership index
<b>2</b>	54.5	48.4	45.3
<b>3</b>	23.9	29.1	27.4

Size of family nucleus %	Basis of household formation		
	Dwelling-based from CSHPR	PR only	PR + partnership index
4	16.5	16.1	19.5
5	3.9	4.6	5.6
6+	1.3	1.9	2.1
<i>Total</i>	<i>100</i>	<i>100</i>	<i>100</i>
<b>Mean size of family nucleus</b>	2.7	2.8	2.9

To compare the methods by **family status**, we exclude CSHPR respondents who meet any of the following criteria:

- 1) Person does not belong to private household by register data.
- 2) Person does not appear in registers as of 1 January 2018 (including 62 babies born during 2018).
- 3) Person's data is insufficient to link register data; their household members are also excluded.

The distribution by family status of the remaining 10,435 respondents is given in Table 5. Differences in distribution are not affected by sample composition, as it is the same with all methods.

In CSHPR households, 45% of people are partners, either married or cohabiting. In PR households, only 35% of the same people are partners. Application of the partnership index increases the share of partners to 45%, i.e. the level of CSHPR. Still, the partnership index tends to overestimate married partners and underestimate consensual union partners. This observation can be explained by marriages' large weight in the partnership model. Virtually all married quasi-couples are classified as partners, although survey data suggests that 10% of them are not (Table 1).

When using the partnership index, the proportion of sons and daughters surpasses CSHPR. This aligns with the overestimating of families with (adult) children. The share of lone parents is close to CSHPR.

**Table 5. Family status**

Family status %	Basis of household formation		
	Dwelling-based from CSHPR	PR only	PR + partnership index
Persons in a married couple	30.1	25.4	32.7
Partners in a consensual union	14.7	9.7	12.5
Lone parents	6.2	10.7	6.6
Sons/daughters, not of lone parent	19.4	16.3	20.9
Sons/daughters of lone parent	8.0	14.4	8.2
Not applicable – not in a family nucleus	21.5	23.5	19.1
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

The data suggests that the main source of error is that young adults are registered in their parental home after moving out. This explains the large number of families with adult children combined with the low number of couples without children in register-based households. In addition, family sizes increase when adult children are considered as members of their parents' families.

This rationale is consistent with the comparison results of CSHPR respondents' actual and registered place of residence. On average, 79% had correct address on the level of building in PR<sup>1</sup>. The same figure was only 59% for 20–24-year-olds and 67% for 25–29-year-olds. False registering also prohibits detecting partnership in youth.

#### 4. Further work

The partnership index validation results in CSHPR are encouraging. However, there is plenty of room for improvement.

We are continuously looking for new data sources to improve the *classification accuracy*. For example, in 2019, we add data on guardianship and custody. The most critical need for new data stems from unreliable registration of youth.

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<sup>1</sup> To obtain population estimates, design weights were adjusted for non-response and calibrated to meet distribution by sex and age in strata.

A Population Act amendment states that starting from 2019, student hostels and dormitories must register their residents' 'place of stay' in PR (Population Register Act, 2000). Hopefully, this will improve *data quality of young adults' residence*. Even under the best scenario, the impact of this regulation is limited, because many young adults live in rented dwellings. In Estonia, very often owners avoid paying income tax on rent, and they are not interested in letting tenants register their property as their place of residence, as it would hint the state about renting.

It is important to ensure that the partnership index gives *consistent results over time*. The patterns of forming and breaking relationship should be realistic. Currently, the algorithm of partnership index does not take into account the preceding years' results, but it may be necessary to add stability to estimates of partnership.

Lastly, dividing residents into families is not enough. Families should also be assigned to dwellings. If a family contains people from different registered addresses, each of these dwellings could be this family's home. Statistics Estonia is making the first steps to develop another index-type methodology that matches *families to dwellings*.

## **5. Conclusions**

The poor place of residence data quality in the Estonian Population Register distorts the distribution of family and household characteristics. The partnership index is a new methodology that attempts to detect cohabiting and married couples who are registered at different addresses. It combines administrative data that connects potential partners and has an impact on the probability of their partnership (e.g. mutual children, co-owning a property). In the Comparative Survey of Household and Place of Residence, the partnership index detected 84% of the couples. When couples matched by partnership index were used to form register-based families, the distributions of family nucleus characteristics improved substantially. Still, the share of families with adult children was overestimated. Better data on the place of residence of young adults is vital to obtain a representative portrayal of Estonian families.

## **6. Acknowledgments**

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