Historical Methods: A Journal of Quantitative and Interdisciplinary History
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t914957648

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Siegfried Gruber[a]; Rembrandt D. Scholz[a]; Mikołaj Szołtysek[a]
[a] Max Planck Institute for Demographic Research, Rostock, Germany

Online publication date: 08 June 2011

To cite this Article Gruber, Siegfried , Scholz, Rembrandt D. and Szołtysek, Mikołaj(2011) 'Real and Synthetic Household Populations and Their Analysis: An Example of Early Historical Census Microdata (Rostock in 1819)', Historical Methods: A Journal of Quantitative and Interdisciplinary History, 44: 2, 107 — 113
To link to this Article: DOI: 10.1080/01615440.2010.517508
URL: http://dx.doi.org/10.1080/01615440.2010.517508

HM
Database Developments
HISTORICAL METHODS, April–June 2011, Volume 44, Number 2

Routledge
Taylor & Francis Group

Real and Synthetic Household Populations and Their Analysis

An Example of Early Historical Census Microdata (Rostock in 1819)

SIEGFRIED GRUBER
REMBRANDT D. SCHOLZ
MIKOŁAJ SZOŁTYSEK
Max Planck Institute for Demographic Research
Rostock, Germany

Abstract. In this article, the authors describe a validation of methods for dealing with census microdata with no delineated households. The 1819 census of Rostock, Germany, is an enumeration of individuals without household reference. Following a description of this census, the authors test an algorithm that constructs households from individual person records according to a strictly defined set of rules. The rules for assigning people to household units are identified by deducing them from the 1867 census of Rostock, which enumerates individuals within household units. The authors then assess the appropriateness of the algorithm's fit to the census of 1819 and conclude with a discussion of the impact of the algorithm on household structures for different groups within the urban population and the strengths and weaknesses of this approach to the construction of synthetic households.

Keywords: algorithm, census, delineating household

Demographers and other social scientists using historical data often are confronted with the tantalizing problems presented by otherwise rich data sources from two or more time periods that report information in inconsistent structures or formats. None of these inconsistencies is more challenging than the organization (or lack thereof) of individual records into households. Such is the case with the 1819 and 1867 censuses of Mecklenburg-Schwerin, Germany. Although the earlier census included a complete enumeration of all individuals living in the Grand Duchy in 1819, it failed to include any indication of household structure or street address.

Fortunately, the census of 1867 did contain information about individuals within households. We decided to apply the information on the structure of enumerated households and their membership in 1867 to identify a set of rules that could be used for assigning individuals to households. We describe here the algorithms that we ultimately used and the process for identifying the best available fit to the data.

Address correspondence to Siegfried Gruber, Max Planck Institute for Demographic Research, Konrad-Zuse-Str 1, 18057, Rostock, Germany. E-mail: gruber@demogr.mpg.de

The Rostock Censuses of 1819 and 1867

The 1819 Census of Mecklenburg-Schwerin is one of the oldest surviving individual-level population censuses in Germany. For the first time, the total population of Mecklenburg-Schwerin was quantitatively and qualitatively recorded. The census was ordered by the Grand Duke of Mecklenburg-Schwerin for the purpose of determining the number of troops that the duchy could supply to the army of the German Confederation (Deutscher Bund). The lists were to constitute a comprehensive register "of every person living on the day of the census, as young or as old as they may be, of every gender, religion, trade or status" (Wochenblatt 1819, 67)[1] Census enumerators were instructed to visit every household during August 1819 and list every person living in that household (Manke 1999).[2]

The census of 1819 contains a wealth of information, especially for such an early census. Data collected include gender, first name, last name, day of birth, place of birth, parish of birth, relationship to household head or occupation, property ownership, duration of residence, marital status, and religion. Because of this richness, the census is widely known as a leading census of the German population of that time (Tscharnke 1943). It was followed by the 1867 census, which used modern refined population-counting methods: the first implemented in Germany in the 1860s. The 1867 census of the Grand Duchy of Mecklenburg-Schwerin was taken on the night of December 2–3, 1867. That night, authorized enumerators visited every house in the district assigned to them, listing every person staying there at that moment in time. The head of each household was responsible for

the correct completion of the census form. The census was conducted according to the rules of the North German Confederation (Norddeutscher Bund) and the German Customs Union (Deutscher Zollverein), which the Grand Duchy of Mecklenburg-Schwerin became part of in 1867–68. The purpose of this census was to provide an overview of both the taxable and conscriptable populations (Manke 2005a, 2005b).

The Rostock censuses of 1819 and 1867 provide a wealth of information that can be used to conduct structural analysis of the family system, as well as changes in these systems over the time period. In analyzing changes in household structures over time using two separate population censuses, a constant effort has to be made to ensure that we compare actually the same unit called a "household." Even slight differences in definitions of a household will yield different results (Schmid 1988). Herein lies the difficulty. Whereas the census of 1867 features borders between households that clearly were assigned during the enumeration process, the census of 1819 delineated no such household borders in the census manuscripts. The 1819 census is simply a list of inhabitants, with no clear designation of where one household ends and where a new household starts. The problem is complicated further by the fact that there is also no information about the addresses of the people in the census manuscripts.

How can we cope with these data insufficiencies? Do they rule out the achievement of our research goals? Is it possible to invent a realistic and meaningful way to delineate households in the 1819 census? If the problem is to be solved, the first step is to define what we mean by "household."

A household has been defined by Peter Laslett (1972, 24) as a coresident domestic group, a "series of names of individuals in blocks, with clear indications of where one block ended and the next began." He further describes this coresident domestic group as having three basic characteristics: The members of the group sleep under the same roof, share a number of activities, and are related to each other by blood or by marriage. The group may occasionally include nonrelated persons—like servants, visitors, boarders, or lodgers—as members of a household (ibid.). Later definitions presented by Richard Wall (2001) concentrate on the first two characteristics. Households are similarly defined in contemporary demographic discourse (Schmid 1988; Ermisch 1988). The apparent straightforwardness of the definitional approach notwithstanding, extracting household data from historical microcensus counts can be a complicated and confusing task. The extreme difficulties we face are similar to those encountered by other scholars working in the field (Berkner 1972; Hammel 1984; Hammel and Wachter 1996a, 1996b; Sovic 2008).

Previous Attempts to Delimit Households

A published version of the Rostock census of 1819, based on a database created for historical research, reports the city's population as represented by households (Manke 2005a). The research team created "households" during data entry of the census: Household units were based on last name, marital status, sex, property, relationship to household head, and occupation (Manke 1997). A household defined in this way would contain the nuclear family of parents and unmarried or economically dependent children, coresident relatives, personnel (domestic servants and employees), and other persons (e.g., boarders and lodgers; Manke 2005a). The basic criteria for being a head of a new household were the following: being of adult age, having no relationship to a member of the previous household or family, and not being an immediate dependent employee. In addition to these relationship criteria, a household head required an income not earned as a live-in employee such as a servant. Matthias Manke (1997, 1999, 2005b) states that this was relatively unproblematic; however, he later became skeptical about the effect of the absence of household borders. On further analysis, he again downplayed this problem in a book about the city of Rostock between 1750 and 1850 (Manke 2000). Inclusion of a person as a mother in law, a father in law, a boarder, or a lodger would have been arbitrary and not in keeping with currently accepted research protocols. As a result, there are a high number of one-person households, often comprising lone elderly individuals (Manke 2005a).

Jürgen Schlumbohm (1994) found a similar census without defined households from 1811–12 in the course of his research in northwestern Germany. He concluded that the order of the people on the enumeration form allows one to create groups of parents, children, and servants. Problems arise with such people as widows, widowers, and older couples. Because of these limitations, he used this census only as a supplementary source.

Although the household assignment rules used by Manke and others might present themselves as relatively straightforward, they consistently led to an overcounting of the number of one-person households (see table 1, 1819 file A)[3] As a consequence, people who lived in a poorhouse or military post were treated as individual households in this digital file, and also in the published edition of the census. Because of the misidentification, a second digital census file that allowed for the creation of institutional households and the inclusion of more people into the households identified in file A was created. The income requirement was also considered in a more restricted way. Because of these refinements in assignment rules, fewer persons in the new file qualified for the status of heading an independent household (see table 1, 1819 file B).

A New Method for Delimiting Households

We decided to test the quality of both census files with an algorithm that creates households according to a strictly defined set of rules. The census of 1867 contained address and household information and, therefore, was not affected by the definitional problems discussed so far. We used this census as our reference point for designing the rules of assigning people to household units and for assessing the appropriateness of the algorithm's fit to the "real" data structures. The

TABLE 1. Comparison of Percentages of Real and Synthetic Household Types

	Percentage by census data file				
Household type	1819 file A	1819 file B	1819 algorithm	1867 file	1867 algorithm
1	27.4	17.4	24.1	17.7	19.7
2	5.4	2.0	2.3	2.7	2.7
3	53.4	75.3	69.1	70.5	68.6
4	13.5	5.1	4.4	8.2	8.7
5	0.1	0.1	0.0	0.1	0.0
6	0.2	0.2	0.2	0.8	0.2
N	4,098	3,601	3,832	6,826	6,694

Note. The household typology is the one suggested by Peter Laslett, "Introduction: The History of the Family," in *Household and Family in Past Time: Comparative Studies in the Size and Structure of the Domestic Group over the Last Three Centuries in England, France, Serbia, Japan and Colonial North America, with Further Materials from Western Europe*, ed. Peter Laslett and Richard Wall, 1–89 (Cambridge: Cambridge University Press, 1972). Type 6 includes institutional households.

process of constructing artificial household structures simulated along a common set of rules for both the 1819 and 1867 censuses has yet another advantage. The two data sets will now be more comparable because we have imposed standard scenarios of household membership on undifferentiated groups of individuals in both enumerations.

Our algorithm was developed in an iterative process, which went back and forth between applying additional rules and evaluating the real data against the simulated structures that resulted from each additional rule. We conducted a number of experiments using various scenarios for assigning individuals to domestic groups, with the goal of obtaining the most satisfactory match with the 1867 census, and, if possible, with the 1819 census, as well. The first assumption in assigning individuals to households is that the members of a household were registered consecutively. Other scholars have tested the data and verified that this assumption is true, despite the fact that the German Customs Union (Deutscher Zollverein) did not require its member states to count the population according to households until 1843 (Manke 2005b)[4] However, the order of persons within a household was not reported in a uniform household sequence of head, wife, children, then servants (ibid.). Therefore, the algorithm could not assume such a sequence.

After several modifications, our algorithm for assigning a person to the previous household consisted of 11 rules:

1. The family name is the same;
2. The occupational title belongs to a list of occupational titles indicating coresidence (e.g., servant, apprentice, journeyman), and the person is unmarried;
3. The relationship to the household head is consistent with this occupation;
4. The occupational title is the same as the previous one, and the person is not married;
5. The person is absent at the time of the census;
6. There are indications that the person belongs to an institutional household (e.g., poorhouse, home for the mentally ill);

TABLE 2. Results of the Synthetic Household Assignment Algorithm

	Census file		
Variable	1819 file A	1819 file B	1867
N households	4,098	3,601	6,826
N households according to algorithm	3,832	3,832	6,694
n household heads not found	421	195	494
Percent household heads not found	10.3	5.4	7.2
n household heads found in both files	3,677	3,406	6,332
Percent household heads found in both files	89.7	94.6	92.8
n Additional household heads created by the algorithm	155	426	362
Percent additional household heads created by the algorithm	3.8	11.8	5.3
n complete matches of households: Not matched	843	700	1,146
Percent complete matches of households: Not matched	20.6	19.4	16.8

7. The person is unmarried and below age 20 years;
8. The person is an unmarried woman below age 25 years;
9. There is no information about the relationship to the household head and no occupational information;
10. The person is a married woman, and there is no information about the relationship of the person to the household head; or
11. The person is an unmarried woman between the ages of 20 and 39 years, and there is no occupational information about her.

The first version of the algorithm comprised only the first four rules. We refined the second rule and added additional rules, reducing mismatches in the first version by about 50 percent. As shown in table 2 the results of the algorithm for the 1867 file are quite good for the first two measures, but are much less satisfactory for the overall measure of complete matches of households. For the 1819 census files, the results of the algorithm reflect variations in the number of households that each file contained initially. The larger number of households in file A leads to a higher number of household heads who are not found by the algorithm and a lower number

TABLE 3. Percentage of Household Heads Matched in Real and Synthetic Households by Gender, Marital Status, and Age

Variable	Complete match (%)	Household heads not found (%)	Additional household heads created by the algorithm (%)	*n* household heads in the data file
1819 file A:				
Male	91.8	8.2	2.0	3, 098
Female	83.4	16.6	9.2	1, 000
Unmarried	52.6	47.4	7.3	715
Married	97.5	2.5	0.9	2, 472
Widowed	97.8	2.2	8.7	911
20–29 years	63.0	37.0	6.8	468
30–39 years	94.6	5.4	3.5	896
40–49 years	95.6	4.4	2.0	858
50–59 years	95.1	4.9	2.0	812
60–69 years	92.2	7.8	4.6	562
70+ years	89.6	10.4	7.8	385
Overall	89.7	10.3	3.8	4, 098
1819 file B:				
Male	96.6	3.4	4.6	2, 873
Female	86.8	13.2	40.2	728
Unmarried	70.9	29.1	27.7	437
Married	97.6	2.4	1.0	2, 466
Widowed	98.7	1.3	40.3	698
20–29 years	82.9	17.1	17.1	328
30–39 years	96.5	3.5	6.4	854
40–49 years	96.7	3.3	4.7	824
50–59 years	96.9	3.1	7.6	754
60–69 years	96.1	3.9	20.9	465
70+ years	91.9	8.1	40.1	284
Overall	94.6	5.4	11.8	3, 601
1867:				
Male	94.6	5.4	5.7	5, 146
Female	87.1	12.9	4.0	1, 680
Unmarried	68.8	31.2	27.4	919
Married	96.8	3.2	1.6	4, 513
Widowed	95.7	4.3	2.2	1, 335
20–29 years	72.4	27.6	29.7	602
30–39 years	95.0	5.0	4.4	1, 771
40–49 years	95.7	4.3	2.5	1, 715
50–59 years	95.3	4.7	2.4	1, 226
60–69 years	95.3	4.7	1.7	969
70+ years	93.7	6.3	2.8	493
Overall	92.8	7.2	5.3	6, 826

Note. The number of household heads may not sum up to the overall number because of missing information about gender, marital status, or age.

TABLE 4. Complete Match of Households: Percentage Not Matched by Household Size and Household Type (Algorithm, Version 7)

	1819 file A		1819 file B		1867	
Variable	%	*n*	%	*n*	%	*n*
Household size						
1	42.7	910	28.3	396	30.5	894
2	13.9	669	12.7	623	13.2	1,057
3	12.1	636	14.6	609	12.0	1,219
4	12.7	561	18.8	580	12.1	1,093
5	14.5	441	18.1	442	13.6	814
6	16.1	317	20.7	324	14.6	595
7	16.3	208	25.3	237	17.8	370
8+	18.0	356	26.7	390	24.5	784
Household type						
1	38.8	1,123	28.8	626	29.0	1,208
2	19.9	221	29.2	72	25.8	186
3	12.2	2,190	16.0	2,710	12.7	4,811
4	15.8	552	33.5	182	15.5	561
5	40.0	5	20.0	5	25.0	4
6	100.0	7	50.0	6	91.1	56
Overall	20.6	4,098	19.4	3,601	16.8	6,826

Note. Household type 6 includes also institutional households.

of additional household heads created by the algorithm. The overall fit is better for file B, which contains fewer households, but ones that have a larger household size, on average. For the most part, however, the effects of using different household limits are minor. Overall, the most important finding of table 2 is that we are confident that more than 80 percent of all households in all files are defined correctly.

The Structure of Synthetic Households

To assess the effects of the algorithm on household structures, we compared the household types in all three files with the typology of households simulated by the algorithm. As shown in table 1, there is almost no difference between real and simulated household structures for the 1867 census. The only minor difference is a slight increase in the number of solitaries at the expense of simple-family households.

The algorithm for the census of 1819 resembles file B to a much greater extent. Most striking are the nearly identical proportions of simple- and extended-family households, as well as other types of domestic groups. The observed mismatch of data for solitary households between simulated files for 1819 and groupings from file B has two implications. First, because we know from the 1867 file that the algorithm generally overestimates solitaries and underestimates simple-family households by approximately 2 percent, the discrepancy between the synthetic household counts and the other files may be somewhat smaller than is suggested in table 1. Different iterations of the algorithm yielded quite similar results, with only a slight tendency to inflate simple- and extended-family households at the expense of solitaries.

Our knowledge of the literature and existing data sets leads us to believe that the proportion of solitaries in 1819 file A is too high. Robert B. Litchfield's (1988) study of nineteenth-century cities found only one case in which the share of households of people living alone or with nonkin only was 18 percent. All other cities had lower percentages (ibid.; Reher 1987). The highest proportion of solitary households ever registered comes from the 1802 census of Reims, where they constituted 19 percent of all domestic groups (Fauve-Chamoux 1983; Duben and Behar 1991). The high proportion of solitaries in file A exceeds all these examples by far.

Algorithm Effects on Different Population Groups

We have seen that the overall match of the algorithm with census data files is quite good, but are aware that there are considerable differences in household structure within the population. Therefore, we want to know which subpopulations the algorithm captures best. Inspection of the results shows that the algorithm matches male household heads much better than female household heads. Married household heads have the highest rates of matches.

Widowed household heads have both low rates of household heads not found by the algorithm and much higher rates of additional household heads created by the algorithm for the 1819 files. Unmarried household heads have very high rates of mismatches, either as household heads not found

by the algorithm or as additional household heads created by the algorithm. The differential matching rates by marital status are also reflected by the variation in the proportion of matches by age group of household heads. Young household heads have the highest rates of mismatches, while middle-aged people have the lowest. These patterns are similar for all three data files; only the extremes are more pronounced for the 1819 data files (see table 3).

In analyzing the effect of the algorithm on the data on individuals within a household, we consider a household to be a complete match if the first person in the respective household and the first person in the next household in the data file match the results obtained by using the algorithm. This analysis is shown in table 4. The fit on household size shows a U shape: high proportions of mismatches of one-person households, low proportions of mismatches for smaller households, and increasing rates of mismatches for larger households. The fit of the algorithm on household typology varies with the complexity of the household. The best fit can be achieved for simple-family households followed by extended-family households. Solitaries and "no-families" have worse rates of matches than these two types. There are very few multiple-family households, households of undetermined type, and institutional households. Overall, we conclude that the algorithm is quite good in detecting simple- or extended-family households. Households that do not contain a couple or a parent-child relationship are more difficult for the algorithm to match with the data file. Servants do not increase the rates of mismatches significantly. However, other nonkin, such as lodgers and those with no identifiable ties to the household, do increase the rate of mismatch.

Conclusion

The results of a comparison of synthetic households constructed by the algorithm with the actual data files are quite reliable at the aggregate level. Results for matches within single households are more questionable, especially for the 1819 files. Therefore, it is suggested that researchers restrict the use of synthetic household data for analysis on an aggregate level when using these files.

TABLE 5. Information Available in the Census

	1819		1867	
Variable	Men (%)	Women (%)	Men (%)	Women (%)
Relationship to household head	41.2	77.7	92.9	93.3
Occupational title	66.2	26.6	79.2	40.1

The synthetic results are better for the census of 1867 than for that of 1819. Clearly, this is because there is more missing data on two key variables in the census of 1819, as summarized in table 5. With more complete information, we can design more precise rules for assigning persons to households in the algorithm. With more precise rules, we would have fewer cases in the troublesome "unknown" category.

Later versions of the algorithm improved its fit to the census data files, but the improvements diminished with every iteration. Improvement in matching household heads in the data files generally led to an increase in the number of additional household heads created by the algorithm. At the moment, we face a trade-off between (a) increasing the matches for household heads (while creating additional "wrong" household heads) and (b) decreasing the number of additional wrong household heads (while decreasing matches of real household heads).[5] Further improvements will require a high investment of time in either designing additional rules or refining existing ones. One approach would be a more thorough analysis of how to use occupational information. Another possibility would be the creation of new *kinds* of rules. For example, we might include a random factor for groups of people for whom we cannot define clear rules for household headship, something like "every other person (of this group type) is a household head."

The algorithm works best for the Rostock "standard" household: a simple-family household with a married or widowed male household head. The matches are worse for all other kinds of households and household heads. This could be related to unintended cultural bias in the algorithm. However, a more plausible explanation is that couples and parent-child relationships are more easily captured by any kind of algorithm than are other kin or nonkin relationships in a given household.

Despite these limitations, the use of an algorithm for constructing and testing synthetic households can help individual scholars decide whether a census data file applying different rules for delimiting households is appropriate for a particular line of research. A census data file with existing household borders in the source material can serve as a reference point in testing an algorithm. Then the algorithm can help the researcher decide about which data file or rules for delimiting households should be used.

NOTES

The authors thank Josh Goldstein (MPIDR) for directing our attention to this possibility for overcoming the deficiencies of the 1819 census, Fred Heiden (MPIDR) for running seven versions of the algorithm, and especially Martin Dinter (MPIDR) for his research assistance and preparation of data sets. The authors thank the University of Rostock, Department for Multimedia and Data Processing (Arbeitsbereich Multimedia und Datenverarbeitung), for the data file of the 1819 census. Research with these data sets has been funded by the Ministry for Education, Science, and Culture of Mecklenburg-Vorpommern (Ministerium für Bildung, Wissenschaft und Kultur Mecklenburg-Vorpommern). An earlier version of this article was presented as part of a paper at the SSHA conference in 2009 and later published as a working paper (Szołtysek et al. 2009).

1. The quote is translated from *Wochenblatt* (1819, 67) by author.

2. The lists were due to be submitted by August 25, 1819. However, taking the census took more time than expected, and the closing date was delayed to mid-November, and then again to early December. The last survey questionnaires were completed as late as in February 1820 (Manke 1999, 650–53).

3. Manke (2000) recognized this overcounting of solitary individuals but did not consider it to be a problem.

4. We have actually found a few households where household heads were registered first and then all the members of their households were listed together later in the file. The number of these cases is too small to affect the outcome of the algorithm.

5. Some changes in the algorithm that improved results for the 1867 data file turned out to have negative effects on the fit for the 1819 data files.

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