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## **Did the Sex Ratio at Birth Reflect Social and Economic Inequalities? A Pilot Study of the Province of Poznań, 1875–1913**

### **Czy wskaźnik proporcji płci przy urodzeniu odzwierciedlał nierówności społeczne i ekonomiczne? Pilotażowe badania prowincji poznańskiej, 1875–1913**

#### **Abstract**

The goal of this study was to examine whether and to what extent sex ratio values at birth may have reflected social and economic inequalities in the Province of Poznań (German: *Provinz Posen*) in the last decades of the 1800s and early 1900s. It was assumed that maternal economic, social and emotional well-being differed according to the size of the place of residence (Poznań / town / village) and

#### **Abstrakt**

Celem pracy było sprawdzenie, czy i w jakim stopniu wskaźnik proporcji płci przy urodzeniu mógł odzwierciedlać nierówności społeczne i ekonomiczne w prowincji poznańskiej w ostatnich dekadach XIX i na początku XX wieku. W pracy założono, że ekonomiczny, społeczny i emocjonalny dobrostan matki różnił się ze względu na wielkość ośrodka zamieszkania (Poznań / miasteczko / wieś) i stan

her marital status (married / unmarried). In the population of the Province, urban areas (e.g., Poznań) and single motherhood were the predictors increasing the chance that the proportion of boys to girls at birth would decline below the biological norm. These factors could affect women during pregnancy through biological (physiological) mechanisms induced by adverse economic conditions (poverty, poor housing conditions, physical effort related to work and spatial mobility) and psychological stress (lack of social approval and support, social instability, occurrence of stigmatization, etc.). It is worth noting, however, that the variability of sex ratio values at birth could also be due to other factors, not identified (captured) in this paper.

### Keywords

urban / rural localities, married / unmarried women, sources of environmental stress, sex ratio at birth, adverse living conditions

cywilny (kobiety niezamężne / mężatki). W populacji zamieszkującej prowincję poznańską obszary miejskie (np. Poznań) i samotne macierzyństwo były predyktorami zwiększającymi szansę na spadek proporcji chłopców do dziewczynek przy urodzeniu poniżej normy biologicznej. Czynniki te mogły działać na kobiety w ciąży poprzez mechanizmy biologiczne (fizjologiczne) indukowane niekorzystnymi warunkami ekonomicznymi (ubóstwo, złe warunki mieszkaniowe, wysiłek fizyczny związany z pracą, mobilność przestrzenna) i stresem psychologicznym (brak aprobaty i wsparcia społecznego, niestabilność społeczna, stygmatyzacja itp.). Warto podkreślić, że zmienność wskaźnika proporcji płci mogła wynikać również z innych czynników, które w tej pracy nie zostały zidentyfikowane (uchwycone).

### Słowa kluczowe

obszary miejskie / wiejskie, kobiety zamężne / niezamężne, źródła stresu środowiskowego, proporcja płci po urodzeniu, niekorzystne warunki życia

## Introduction

According to biological law, 105–107 boys come into the world per 100 girls born alive.<sup>1</sup> In research on historical populations, the number of live-born boys to

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<sup>1</sup> Luigi Luca Cavalli-Sforza, Walter Fred Bodmer, *The Genetics of Human Populations* (San Francisco: Freeman, 1971); William Henry James, "The Human Sex Ratio. Part 1: A Review of the Literature," *Human Biology* 59 (1987): 721–752; idem, "The Human Sex Ratio. Part 2: A Hypothesis and a Program of Research," *Human Biology* 59 (1987): 873–900. The mechanism of sex determination is described by Piprek and Kubiak in Rafał P. Piprek, Jacek Z. Kubiak, "Historia badań nad determinacją płci," *Kosmos* 68 (4): 523–533.

the number of live-born girls (sex ratio at birth, hereinafter SRB)<sup>2</sup> is a simple test of the reliability of historical sources.<sup>3</sup> A lower SRB value could indicate a weaker registration of male newborns, while a higher SRB value could suggest a weaker registration of female births. Fluctuations of the sex ratio at birth, resulting from an underestimation of the number of newborn babies, have been indicated by studies by historical demographers. Cezary Kukło,<sup>4</sup> in his study of the 18th-century Parish of the Holy Cross in Warsaw, observed fluctuations in the SRB. Very high SRB values of 124 and 168 males per 100 females were noted for the periods 1730–1739 and 1740–1749 respectively. According to the author, they resulted from “a considerable advantage of baptized male infants over female infants (...)” Rachwał<sup>5</sup> showed unstable values of the ratio of live-born boys to live-born girls in a comprehensive study of demographic processes taking place in the Lublin region from the 17th to the early 20th centuries. In some parishes, the masculinization rate of newborns reached 82.7%, while in others almost 136%, which resulted from the low number of baptism registrations of boys or girls respectively. The author also linked the “under-registration” of boys at baptism to epidemics that could have a greater effect on the biologically weaker male sex, “causing increased mortality just after birth and consequently a failure to register some of the dead newborns.”<sup>6</sup> In the Catholic parishes from Toruń studied by Agnieszka Zielińska,<sup>7</sup> male births usually prevailed (SRB values of even 125 or 128), but as the author pointed out, the value of the index began to normalize only from the 1860s, which was influenced by the increase in number of the city’s faithful. Occasionally, values below 100 indicated that live-born girls outnumbered live-born boys, which was certainly associated with deficiencies in registration. Edmund Piasecki<sup>8</sup> also recorded low (97%) and high (122%) SRB values in Bejsce parish. Ján Golian<sup>9</sup> indicated fluctuations in SRB values in Detva parish, located in the region of Podpoľanie, Central Slovakia, in the first half of the 19th century.

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<sup>2</sup> Also the secondary sex ratio / the masculinization rate of newborns; see literature cited at the end of this paper.

<sup>3</sup> Edmund Piasecki, *Ludność parafii bejskiej (woj. kieleckie) w świetle ksiąg metrykalnych z XVIII–XX w. Studium demograficzne* (Warszawa–Wrocław: Wydawnictwo Naukowe PWN, 1990), 45.

<sup>4</sup> Cezary Kukło, *The Population of the Holy Cross Parish in Warsaw in the 18th Century* (Białystok: Institute for Research of European Cultural Heritage, 2016), 38.

<sup>5</sup> Piotr Rachwał, *Ruch naturalny ludności rzymskokatolickiej w Lubelskiem w świetle rejestracji metrykalnej z lat 1582–1900* (Lublin: Wydawnictwo KUL, 2019).

<sup>6</sup> Rachwał, *Ruch*, 237.

<sup>7</sup> Agnieszka Zielińska, *Przemiany struktur demograficznych w Toruniu w XIX i na początku XX wieku* (Toruń: Wydawnictwo Adam Marszałek, 2012).

<sup>8</sup> Piasecki, *Ludność*.

<sup>9</sup> Ján Golian, *Život ľudu detvianskýho. Historicko-demografická a kultúrna sonda do každodenného života v dlhom 19. Storočí* (Ružomberok: The Society for Human Studies, 2019).

According to Golian, this fact was closely related to poor parish registration in the first decades of the 19th century; an improvement was observed only in the second half of the 19th century. Meanwhile Jan Paradysz<sup>10</sup> was quite critical of the use of the number of live-born boys to the number of live-born girls as a measure of the accuracy of historical registration. He pointed out that the SRB value should always be related to the sample size, i.e., the number of births, bearing in mind possible random errors.<sup>11</sup> The same opinion is shared by Cezary Kukło<sup>12</sup> who, quoting Henry,<sup>13</sup> claims that the masculinization index is a very good indicator of the completeness of registration but model values of this index are observed only in large groups.

Researchers have also pointed out that the higher sex ratio values in historical and contemporary populations could have social reasons, i.e., in female discrimination through poor treatment of infants (e.g., shorter breastfeeding periods, poorer nutrition and poor medical care for sick newborns), and girls and women later in life (the neglect of girls in families, poorer healthcare and nutrition for female children).<sup>14</sup> Linda Mealey and Wade Mackey,<sup>15</sup> in reference to the 19th-century Mormon population, indicated the conscious manipulation of the offspring sex ratio by mothers from different social status according to their access to a livelihood. Scott and Duncan<sup>16</sup> observed differences in sex-biased investment strategies in child feeding between social groups in the population of northern England (1600–1800). The sex ratios at birth outside of the biological norm of 105–107 boys per 100 female babies are still a problem observed in some parts of the world. In 2011 the annual estimate of the SRB for China was 117, in the Indian states of Punjab, Haryana and Uttar Pradesh the SRB values in 2008–2010 were 120, 118 and 115 respectively, while at the same time in Azerbaijan, Armenia and Georgia the values were 116, 115 and 114 respectively, and in Albania

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<sup>10</sup> Jan Paradysz, “Współczesna demografia regionalna i kilka wniosków z niej wypływających dla innych badań w mikroskali,” *Przeszłość Demograficzna Polski* 26 (2005): 167–189.

<sup>11</sup> Paradysz, “Współczesna demografia,” 170.

<sup>12</sup> Cezary Kukło, *Demografii historycznej wkład do nauk o rodzinie*, XVII Warsztaty Antropologiczne im. Profesora Janusza Charzewskiego, Łódź 2016.

<sup>13</sup> Louis Henry, *Techniques d'analyse en démographie historique* (Paris: Éditions de INED, 1980).

<sup>14</sup> Sara Horrell, Deborah Oxley, “Gender Bias in 19th Century England: Evidence from Factory Children,” *Economics & Human Biology* 22 (2016): 47–64; Katherine A. Lynch, “Why Weren’t (Many) European Women ‘Missing?’” *History of the Family* 16 (2011), 3: 250–266; Francisco J. Beltrán Tapia, Domingo Gallego-Martínez, “What Explains the Missing Girls in Nineteenth-Century Spain?” *Economic History Review* 73 (2020): 59–77.

<sup>15</sup> Linda Mealey, Wade Mackey, “Variation in Offspring Sex Ratio in Women of Differing Social Status,” *Ethology and Sociobiology* 11 (1990), 2: 83–95.

<sup>16</sup> Susan Scott, C.J. Duncan, “Reproductive Strategies and Sex-Biased Investment,” *Human Nature* 10 (1999): 85–108.

and Montenegro they were 112 and 110 respectively.<sup>17</sup> Prenatal sex determination (sex-selective abortion) is a widespread practice responsible for the right-skewed value of sex ratio at birth and has a cultural background, related to favoring the male sex in some societies.<sup>18</sup> In modern populations, disturbances in sex ratio are observed not only in newborns but also in older children. Jayachandran and Kuziemko<sup>19</sup> showed that in India, mothers breastfeed sons longer than daughters, which contributes to missing women there.

Meanwhile, numerous medical and biological studies have linked the fluctuation of male-to-female live births with extreme exogenous shocks, the so-called environmental stresses caused by natural disasters, wars, political and social upheavals, etc.<sup>20</sup> There are two ways to interpret this state of affairs. Firstly, exogenous stressors could decrease the odds of male conceptions by a reduction in the frequency of coitus in the population. Reduced coitus, particularly early in the human menstrual cycle, is responsible for a decline in the conception of males.<sup>21</sup> Under the influence of stress, male hormones significantly reduce the quantity and quality of sperm,<sup>22</sup> which leads to negative changes in sperm motility.<sup>23</sup> The second interpretation has pointed out that adverse stressful events lead to the secretion of stress hormones, which affect either the selection of zygote sex at conception, e.g., by disturbing the processes of determining of male fetus formation,<sup>24</sup> or the spontaneous selective abortion of male fetuses. Both modifications ultimately lead to a reduction in the number of live male births.<sup>25</sup> In other words, the form

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<sup>17</sup> *Sex Imbalances at Birth: Current Trends, Consequences and Policy Implication* (Bangkok: UNFPA Asia and the Pacific Regional Office Bangkok, 2012).

<sup>18</sup> Christophe Z. Guilmoto, *High Sex Ratio at Birth in Southeast Europe* (Paris: CEPED, Université Paris-Descartes, 2012), <http://www.demographie.net/guilmoto/pdf/research%20note%20on%20BM%20in%20SE%20Europe4.pdf>; see also Lynch, "Why Weren't (Many) European Women 'Missing'?", *Sex Imbalances at Birth*.

<sup>19</sup> Seema Jayachandran, Ilyana Kuziemko, "Why Do Mothers Breastfeed Girls Less than Boys? Evidence and Implications for Child Health in India," *The Quarterly Journal of Economics* 126 (2011), 3: 1485–1538.

<sup>20</sup> E.g., Ralph Catalano et al., "Exogenous Shocks to the Human Sex Ratio: The Case of September 11, 2001 in New York City," *Human Reproduction* 21 (2006): 3127–3131; Misao Fukuda et al., "Kobe Earthquake and Reduced Sperm Motility," *Human Reproduction* 11 (1996): 1244–1246.

<sup>21</sup> Catalano et al., "Exogenous Shocks"; William Henry James, "Regional Differences Invalidate U.S. Sperm Trend Conclusions," *Environmental Health Perspectives* 107 (1999), 3: A132.

<sup>22</sup> Fukuda et al., "Kobe Earthquake."

<sup>23</sup> Branko Zorn et al., "Semen Quality Changes among Slovenian Healthy Men Included in the IVF-ET Programme during 1983–1996," *International Journal of Andrology* 22 (1999): 178–183.

<sup>24</sup> Fukuda et al., "Kobe earthquake."

<sup>25</sup> Julianne Byrne, Dorothy Warburton, John Opitz and James Reynolds, "Male Excess among Anatomically Normal Fetuses in Spontaneous Abortions," *American Journal of Medical Genetics* 26 (1987): 605–611; Tim Bruckner, Ralph Catalano, "The Sex Ratio and Age-Specific Male Mortality: Evidence for Culling in Utero," *American Journal of Human Biology* 19 (2007): 763–773; Catalano et al., "Exogenous shocks"; Ralph Catalano et. al., "Gender-Specific Selection in Utero

of responses to acute environmental stress is the modification of the natural sex ratio of the offspring, which manifests itself in a decrease in the SRB value.<sup>26</sup> Therefore, the index of male-to-female live births is considered a “measure” of adverse environmental conditions caused by ecological, economic, or political factors, etc. Studies of contemporary and historical populations have shown that wars, armed conflicts and economic crises can be sources of stress for the human body, including that of a pregnant woman. A decline in the SRB was noted in the US in 1964, a few months after President Kennedy’s assassination, and in 2002 following the terrorist attack on WTC on September 11, 2001.<sup>27</sup> Similarly, a decline in the proportion of live-born males to females was observed in Slovenia a few months after the so-called “short war” of 26 June–7 July, 1991<sup>28</sup> and during the Iran War in 1980–1988.<sup>29</sup> Natural disasters such as earthquakes were also responsible for a fall in the SRB below the biological norm. This was confirmed by research on the population in Japan which was exposed to earthquakes in 1995<sup>30</sup> and 2011,<sup>31</sup> and in Chile a few months after the 2005 earthquake.<sup>32</sup> Altered sex ratios after the London smog in 1952 and the Brisbane flood in 1965 were also noted in the literature.<sup>33</sup> A decline in the SRB in China was observed shortly after the end of the 1959–1961 Great Leap Forward Famine.<sup>34</sup> In East Germany in 1991,

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among Contemporary Human Birth Cohorts,” *Paediatric and Perinatal Epidemiology* 23 (2009): 273–278; Dorthe Hansen, Henrik Moller, Jorn Olsen, “Severe Periconceptional Life Events and the Sex Ratio in Offspring: Follow up Study Based on five National Registers,” *BMJ* 319 (1999): 48–549; Florencia Torche, Karine Kleinhaus, “Prenatal Stress, Gestational Age and Secondary Sex Ratio: The Sex-specific Effects of Exposure to a Natural Disaster in Early Pregnancy,” *Human Reproduction* 27 (2011): 558–567.

<sup>26</sup> Elżbieta Żądzińska et. al., “Can Economic Stress Affect Secondary Sex Ratio in Poland?” *Anthropological Review* 77 (2007): 15–27; Elżbieta Żądzińska et al., “Zastosowanie modeli ARI-MA w badaniach nad stresem ekonomicznym wpływającym na kondycję biologiczną populacji ludzkich,” *Acta Universitatis Lodzensis. Folia Oeconomica* 271 (2012): 85–98.

<sup>27</sup> Victor Grech, “Secular Trends in Newborn Sex Ratios,” *Early Human Development* 90 (2014), 11: 755–760; idem, “Ethnic Differences in Birth Gender Ratio Responses in the United States after the September 11 Attacks and the President Kennedy Assassination,” *Early Human Development* 91 (2015), 12: 829–836.

<sup>28</sup> Branko Zorn et al., “Decline in Sex Ratio at Birth after 10-Day War in Slovenia,” *Human Reproduction* 17, (2002), 12: 3173–3177.

<sup>29</sup> M. Ansari-Lari, M. Saadat, “Changing Sex Ratio in Iran, 1976–2000,” *Journal of Epidemiology and Community Health* 58 (2002), 6: 622–623.

<sup>30</sup> Fukuda et al., “Kobe earthquake.”

<sup>31</sup> Kohta Suzuki et al., “Effects of the Great East Japan Earthquake on Secondary Sex Ratio and Perinatal Outcomes,” *Journal of Epidemiology* 26 (2016): 76–83.

<sup>32</sup> Torche, Kleinhaus, “Prenatal Stress.”

<sup>33</sup> W.R. Lyster, “Altered Sex Ratio after the London Smog of 1952 and the Brisbane Flood of 1965,” *British Journal of Obstetrics and Gynaecology* 81 (1974): 626–631.

<sup>34</sup> Shige Song, “Does Famine Influence Sex Ratio at Birth? Evidence from the 1959–1961 Great Leap Forward Famine in China,” *Proceedings. Biological Sciences* 279 (2012), 1739: 2883–2890.

a decline in the proportion of males to females was caused by the collapse of the economy following the fall of the Berlin Wall<sup>35</sup>.

In light of the above considerations, the aim of our work is to examine whether and to what extent the sex ratio at birth may have reflected maternal social and economic inequalities in the Province of Poznań in the late 1800s and early 1900s. It was assumed that maternal economic, social and emotional well-being differed according to the size of the place of residence, and marital status. Adverse living conditions affecting women during pregnancy had a negative effect on the course of pregnancy, translating into various perinatal outcomes including a decline in the number of boys to girls at birth, below the biological norm.

### Characterization of Material

The study uses aggregate data on the numbers of births in subsequent months of the years 1875–1913. They were derived from the Prussian Statistical Yearbooks (*Preussische Statistik*).<sup>36</sup> These are currently deposited in the Adam Mickiewicz University Library in Poznań. Volumes were missing for the following years: 1882, 1886, 1894–1897, 1904, 1909–1911. In total 2,249,039 aggregate numbers of live births were collected, including 1,154,199 live-born males and 1,094,840 live-born females.

In Prussia and in Poland under the Prussian partition, population censuses and vital statistics were regulated by the Prussian *Landrecht* and detailed rules. Until Civil State Offices came into operation the main source of information on births, marriages and deaths had been parish records. In 1874 Civil State Offices were set up throughout the Prussian state. Along with priests, officials of the civil state became responsible for the registration of demographic events. In the same year special acts regulating registrations were introduced to the provinces.<sup>37</sup> For example, §13 of the 1874 act prescribed that every birth of a child had to be reported within seven days. At the end of each calendar year, priests, pastors and superintendents sent standardized overall tables containing vital statistics data to

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<sup>35</sup> Ralph A. Catalano, "Sex Ratios in the Two Germanies: A Test of the Economic Stress Hypothesis," *Human Reproduction* 18 (2003), 9: 1972–1975.

<sup>36</sup> *Preussische Statistik. Die Bewegung der Bevölkerung. Die Geburten, Eheschließungen und Sterbefälle. Herausgegeben in zwanglosen Heften vom Königl. Preussischen Statistischen Bureau in Berlin* (Berlin: Königl. Preussischen Statistischen Bureau in Berlin, 1876 Heft 42, 1878 Heft 45, 1879 Heft 48, 1880 Heft 51, 1881 Heft 56, 1882 Heft 61, 1882 Heft 72, 1884 Heft 79, 1885 Heft 87, 1886 Heft 89, 1889 Heft 96, 1890 Heft 107, 1890 Heft 113, 1892 Heft 117, 1893 Heft 125, 1893 Heft 127, 1895 Heft 134, 1900 Heft 160, 1901 Heft 161, 1903 Heft 178, 1905 Heft 190, 1906 Heft 200, 1907 Heft 207, 1908 Heft 213, 1909 Heft 220, 1913 Heft 238, 1914 Heft 245).

<sup>37</sup> *Extra Beilage zum Amtsblatt der Königlichen Regierung zu Posen* (Posen 1874), 1–40.



the administration of counties (*Kreis*), from which the data were sent to offices at the region level (*Regierungsbezirk*), then to that of the province (*Provinz*), and finally to the Central Statistical Office in Berlin,<sup>38</sup> where all the statistics were collected, processed and published. From 1861 onwards, the Royal Prussian Statistical Office (German: *Königlich Preußisches Statistisches Landesamt*) in Berlin started to publish a statistical book on a yearly basis. By 1934, a total of 270 yearbooks had been issued, containing aggregated demographic, medical, economic, and climatic data.<sup>39</sup> It is worth emphasizing that the Prussian statistics are characterized by extraordinarily high standards and reliability, so they deserve researchers' attention. Although Wajda<sup>40</sup> complained about the "too aggregated nature of the data" and the limited usefulness of Prussian vital statistics for demographic studies, to this day they have formed the basis of studies of Greater Poland,<sup>41</sup> Silesia,<sup>42</sup> Pomerania,<sup>43</sup> and the Kingdom of Prussia.<sup>44</sup> The assessment of the reliability and validity of the Prussian statistics was a crucial part of many previous studies and in the light of the criticism of their reliability they were considered as meeting the required criteria and fit for use for demographic analysis.<sup>45</sup>

Aggregate birth statistics were provided for the whole year (German: *im ganzen Jahre*) and for the months of subsequent years, from January to December, separately for types of centers differing in size. Such tables were called *Type of Place*

<sup>38</sup> Kaczmarek, Bogusław. "Ocena spisów ludności na Śląsku z pierwszej połowy XIX wieku," *Przeszłość Demograficzna Polski* 1 (1967): 33–63; Mieczysław Kędelski, "Umieralność i trwanie życia w Wielkopolsce w latach 1818–1875," *Przeszłość Demograficzna Polski* 16 (1985): 109–138.

<sup>39</sup> Michael Haines, *Economic-demographic Interrelations in Developing Agricultural Regions. A Case Study of Prussian Upper Silesia 1840–1914* (New York: Arno Press, 1977); Grażyna Liczbińska, *Lutherans in the Poznań Province. Biological Dynamics of the Lutheran Population in the 19th and Early 20th Centuries* (Hamburg: Verlag Dr. Kovač, 2015).

<sup>40</sup> Kazimierz Wajda, "Uwagi do wytycznych," *Przeszłość Demograficzna Polski* 12 (1980): 193–200.

<sup>41</sup> Stanisław Borowski, "Zgony i wiek zmarłych w Wielkopolsce w latach 1806–1914," *Przeszłość Demograficzna Polski* 1 (1967): 111–130; Alicja Budnik, Grażyna Liczbińska, "Urban and Rural Differences in Mortality and Causes of Death in Historical Poland," *American Journal of Physical Anthropology* 129 (2006): 294–304; Mieczysław Kędelski, "Próba rekonstrukcji porządku wymierania w Wielkopolsce w okresie rewolucji demograficznej," *Przeszłość Demograficzna Polski* 12 (1980): 47–65; idem, "Umieralność"; Grażyna Liczbińska, *Umieralność i jej uwarunkowania wśród katolickiej i ewangelickiej ludności historycznego Poznania* (Poznań: Biblioteka Telgte, 2009); eadem, *Lutherans*.

<sup>42</sup> Haines, *Economic-demographic Interrelations*; Kaczmarek, "Ocena".

<sup>43</sup> Grażyna Liczbińska, "Biological and Social Reason of Child Mortality in the Danzig District in the Second Half of the 19th Century," *Anthropological Review* 62 (1999): 85–92; Zbigniew Klotzke, "Ludność obwodu Urzędu Stanu Cywilnego Luzino w latach 1874–1918," *Przeszłość Demograficzna Polski* 12 (1980): 65–104.

<sup>44</sup> Bronisław Wojtun, "Ocena jakości pruskiej statystyki ludnościowej przy użyciu równań bilansujących," *Przeszłość Demograficzna Polski* 9 (1976): 27–40.

<sup>45</sup> The results of the assessment of reliability and validity of the Prussian statistics were published by Liczbińska, *Lutherans*, 20–25.



of Residence (German: *Charakter der Wohnplätze*). Three types of centers were distinguished by Prussian statisticians: rural areas (*Landgemeinden*), town areas (*Stadtgemeinden*) and cities with at least 20,000 inhabitants (*Städte mit 20000 Einwohner und drüber*). The city of Poznań (German: *Posen*), the capital of the Province of Poznań, was in the last category. In the Prussian sector, rural areas (*Landgemeinden*) had an individual character, and thus encompassed individual villages and land estates. Towns with fewer than 20,000 inhabitants were included by Prussian statisticians in the category *Stadtgemeinden* (towns)<sup>46</sup>. When publishing statistics for centers of residence, account was also taken of whether a child was born to a married or unmarried mother (a column called marital status; German: *Familienstand*). In this group, two categories were distinguished by Prussian statisticians: children born in wedlock (German: *in der Ehe, ehelich*) or children born out of wedlock (German: *ausser der Ehe, unehelich*).

First, in 3 separate Excel sheets (for rural areas, towns and Poznań, respectively), the numbers of live-born boys and girls in particular years were collated, separately for legitimate and illegitimate births. Then the sheets were combined into one, consisting of information on the numbers of males and females born alive, with the year of birth, maternal place of residence and her marital status. The material is shown in Table 1.

Table 1. Number of male and female live births by maternal place of residence and her marital status

Place of residence	Married		Unmarried	
	males	females	males	females
Poznań	40,458	38,002	5,387	5,293
Towns	261,635	249,625	24,714	23,662
Rural areas	781,795	739,496	40,210	38,762

Source: *Preußische Statistik. Die Bewegung der Bevölkerung*.

## Methods

From the numbers of live-born males and females the sex ratios at birth were calculated. Maternal socioeconomic status was described according to following variables: “maternal place of residence at delivery” and “maternal marital status at the moment of delivery.” The first variable included 3 categories: 0) Poznań, i.e., the capital city of the Province of Poznań, 1) towns, and 2) rural areas.

<sup>46</sup> Liczbińska, *Lutherans*; Kędelski, “Próba”; Wajda, “Uwagi.”

The variable “maternal marital status at delivery” allowed two categories to be distinguished: 0) unmarried mother, i.e., an illegitimate child was born, 1) a married mother. In relation to historical and contemporary populations the size of the place of residence and marital status are commonly used indicators of socioeconomic status. These indicators were associated with differences in the standard and quality of life, which was reflected in the stratification of many biological and demographic characteristics.<sup>47</sup>

Mean values ( $\bar{x}$ ), medians (Me), standard deviations (SD), and lower (Q1) and upper quartile values (Q3) of SRB were computed for the material as a whole as well as according to the maternal place of residence and her marital status. Differences in the SRB values were verified by one-way analysis of variance (ANOVA). If the assumption about the homogeneity of variance was not met, differences in SRB were tested with the use of the non-parametric Kruskal-Wallis test by ranks. Generalized Linear Models (GLMs) with binomial error distribution and the logit link function were used to verify which predictors of maternal socioeconomic status: place of residence (Poznań / towns / rural areas) and her marital status (unmarried / married) were significantly associated with the chance that the sex ratio at birth would be below the biological range of 105–107 boys per 100 girls. The sex ratio at birth was used as a response variable, while the maternal place of residence and her marital status as explanatory ones. The odds ratios and their 95% confidence intervals (CI) were calculated to characterize the effect of the explanatory variables on the binary response. Odds ratios allowed the assessment that the risk of sex ratio at birth would be below the biological norm depending on the categories of maternal place of residence and marital status. To assess the performance of the model areas under ROC (receiver operating characteristics), curves (AUC) were calculated. The area under the ROC curve measures

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<sup>47</sup> E.g., Budnik, Liczbińska, “Urban and Rural Differences”; Grażyna Liczbińska, “Diseases, Health Status and Mortality in Urban and Rural Environments: The Case of Catholics and Lutherans in 19th-Century Greater Poland.” *Anthropological Review* 73 (2010): 21–36; eadem, *Lutherans*; Grażyna Liczbińska et al., “Body Mass Index Values of Conscripts in the Polish Lands under Prussian Rule in the Late 19th and Early 20th Centuries,” *Economics and Human Biology* 21 (2016): 75–83; Grażyna Liczbińska et al., “Marital Fertility and the Family in Poland from the Late Nineteenth to the Early Twentieth Century,” *Journal of Interdisciplinary History* 49 (2018), 2: 279–303; Anna Lipowicz, Monika Lopuszanska, “Marital Differences in Blood Pressure and the Risk of Hypertension among Polish Men,” *European Journal of Epidemiology* 20 (2005): 421–427; Monika Łopuszańska-Dawid et al. “The Relationship between: Occupational Status, Biological Condition and Androgen Hormone Level among Polish Adult Men: The Wrocław Male Study,” *The Aging Male* 19 (2016): 231–238; Alicja Szklarska et al., “Biological Condition of Adult Migrants and Non-Migrants in Wrocław, Poland,” *American Journal of Physical Anthropology* 20 (2008): 139–145.

the decisiveness and accuracy of the model, i.e., it compares different models for a particular variable and assesses the performance of the model.<sup>48</sup>

All statistical analyses were carried out using STATISTICA version 12.0.<sup>49</sup> Significance was set at  $p < 0.005$  and  $p < 0.001$ .

## Results

The chi-square test checked the distribution of the SRB values according to the maternal place of residence and maternal marital status. It was assumed that a range of 105–107 boys born alive per 100 girls is the biological norm of sex proportion in human populations,<sup>50</sup> and 3 categories of the SRB values were separated: 0) SRB < 105; 1) SRB = 105–107; 2) SRB > 107. In the Province of Poznań, among the 3 centers differing in size, it was rural areas where the SRB was most often in the range 105–107, while in Poznań it was the least often ( $\chi^2 = 62.72$ ,  $df = 4$ ,  $p < 0.001$ ). In the case of the marital status of the women from the province, the SRB values 105–107 were observed more frequently in married women than unmarried ( $\chi^2 = 120.32$ ,  $df = 2$ ,  $p < 0.001$ ).

In the entire Province, the statistics of sex ratio at birth are as follows: = 105; Me = 105; SD=7.5. In the capital of the Province, the city of Poznań, the SRB value was at the level of  $103.8 \pm 9.5$ , Me = 104, in towns –  $104.8 \pm 7.1$ , Me = 104, while in rural areas it was  $105.0 \pm 6.4$ , Me = 105. In Poznań, towns and rural areas the central 50% quartiles (Q1–Q3) of the SRB values range from 95–112, 100–110 and 102–109 respectively. The Kruskal-Wallis test did not confirm differences in the SRB between the centers at a statistical level ( $p > 0.05$ ). The value of the SRB according to maternal marital status differed significantly, being lower for unmarried mothers:  $103.5 \pm 9.3$ , Me = 103 than married ones:  $105.3 \pm 6.0$ , Me = 105 (Kruskal-Wallis test:  $H = 13.4$ ,  $p < 0.001$ ). The central Q1–Q3 of SRB in unmarried and married mothers was 96–112 and 102–109 respectively.

The ROC curves with AUC placed between 0.7–0.72 showed that the accuracy of a decision for the risk of sex ratio at birth values based on maternal SES characteristics represented a poor test. However, GLMs revealed that maternal place of residence and her marital status affected sex proportion at birth. The directions of the effects were positive, and odds ratios were above 1. This means that the

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<sup>48</sup> Andrzej Stanisław, *Przystępny kurs statystyki z zastosowaniem STATISTICA PL na przykładach medycyny*, t. 2: *Modele liniowe i nieliniowe*. StatSoft Kraków, 2007; see also in Magdalena Kosińska, Tomasz Hadada, Grażyna Liczbińska, “Does Extreme Maternal Age Still Act as a Risk Factor for Adverse Perinatal Outcome? Evidence from Poland 20 Years after the Social and Economic Transformation,” *Anthropological Review* 82 (2019): 125–137.

<sup>49</sup> Stat Soft, Inc. 2019; STATISTICA version 12.0, www.statsoft.com.

<sup>50</sup> Cavalli-Sforza, Bodmer, *The Genetics*.

odds of events (here: the sex ratios at birth < the range of 105–107 boys born alive per 100 girls) were greater in the cities than in the rural areas of the Province, and greater among unmarried women than in mothers living in matrimony (Table 2). The same pattern was confirmed when the sex ratio values at birth of lower than 90 boys per 100 girls were excluded from analysis, as considered the extreme low (Table 3).

Table 2. Model coefficients and odds ratios explaining the influence of maternal marital status and her place of residence on the sex ratio at birth below the value 105–107 boys born per 100 girls

Explanatory variables	Estimate	SE	+95 CL	–95% CL	OR (95% CI)
Place of residence					
Poznań	0.43	0.06	0.30	0.55	2.36 (1.84–3.03)*
Towns	0.17	0.06	0.05	0.28	1.14 (1.12–1.77)**
Villages <sup>a</sup>					
Marital status					
Unmarried	0.45	0.05	0.35	0.55	2.47 (2.02–3.01)*
Married <sup>a</sup>					

Abbreviations: SE – standard error; CL – confidence level; OR – odds ratio; CI – confidence interval.

<sup>a</sup> Omitted category is reference group.

\* Significant  $p < 0.001$ ; \*\* Significant  $p < 0.005$ .

Source: *Preußische Statistik. Die Bewegung der Bevölkerung.*

Table 3. Model coefficients and odds ratios explaining the influence of maternal marital status and her place of residence on the sex ratio at birth below the value of 105–107 boys born per 100 girls (SRB < 90 excluded from analysis)

Explanatory variables	Estimate	SE	+95 CL	–95% CL	OR (95% CI)
Place of residence					
Poznań	0.76	0.12	0.53	0.99	4.54 (2.87–3.18)*
Towns	0.36	0.09	0.19	0.53	2.06 (1.46–2.91)*
Villages <sup>a</sup>					
Marital status					
Unmarried	0.79	0.09	0.59	0.98	4.82 (3.27–4.10)*
Married <sup>a</sup>					

Abbreviations: SE – standard error; CL – confidence level; OR – odds ratio; CI – confidence interval.

<sup>a</sup> Omitted category is reference group.

\* Significant  $p < 0.001$ .

Source: *Preußische Statistik. Die Bewegung der Bevölkerung.*

## Discussion

Maternal stress during pregnancy has a negative effect on the course of pregnancy and the perinatal outcome of newborns.<sup>51</sup> It contributes to a delay in fetal intrauterine growth, a low birth weight,<sup>52</sup> and causes premature births.<sup>53</sup> It also leads to frequent spontaneous miscarriages of male fetuses,<sup>54</sup> since males are at greater risk of death or damage during pregnancy than females,<sup>55</sup> which is ultimately reflected in the decline of the proportion of males to females at birth.<sup>56</sup> In contemporary human populations sources of environmental stress are very diverse: from chemical contaminants such as TCDD (dioxin),<sup>57</sup> pesticides,<sup>58</sup> car exhaust fumes,<sup>59</sup> radioactive substances,<sup>60</sup> and the mother's addiction to smoking

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<sup>51</sup> Gail A. Barbosa, "The Association of Life Events to Gestational Age at Delivery among Low-Income, Urban, African American Women," *Journal of Perinatology* 20 (2000): 438–442; Laura M. Glynn et. al., "When Stress Happens Matters: Effects of Earthquake Timing on Stress Responsivity in Pregnancy," *American Journal of Obstetrics and Gynecology* 184 (2001): 637–642; Grażyna Liczbińska, Miroslav Králík, "Body Size at Birth in Babies Born during WWII: The Evidence from Poland," *American Journal of Human Biology* 32 (2020): e23421; Heather Lipkind et. al., "Birth Outcomes among Offspring of Women Exposed to the September 11, 2001, Terrorist Attacks," *American Journal of Obstetrics and Gynecology* 116 (2010): 917–925; Torche, Kleinhaus, "Prenatal Stress"; Xu Xiong et. al., "Exposure to Hurricane Katrina, Post-traumatic Stress Disorder and Birth Outcomes," *The American Journal of the Medical Sciences* 336 (2008): 111–115; Peng Zhu et. al., "Prenatal Life Events Stress: Implications for Preterm Birth and Infant Birthweight," *American Journal of Obstetrics and Gynecology* 203 (2010): 1–8.

<sup>52</sup> Henry William James, "Proximate Causes of the Variation of the Human Sex Ratio at Birth," *Early Human Development* 91 (2015): 795–799.

<sup>53</sup> Ralph Catalano, Hans-Tore Hansen, Terry Hartig, "The Ecological Effect of Unemployment on the Incidence of Very Low Birthweight in Norway and Sweden," *Journal of Health and Social Behavior* 40 (1990): 422–428; Ralph Catalano et. al., "Sex Ratios in California Following the Terrorist Attacks of September 11, 2001," *Human Reproduction* 20 (2005): 1221–1227; Torche, Kleinhaus, "Prenatal Stress."

<sup>54</sup> Liczbińska, Kralík, "Body Size"; Torche, Kleinhaus, "Prenatal Stress."

<sup>55</sup> Reiko Mizuno, "The Male/Female Ratio of Fetal Deaths and Births in Japan," *The Lancet* 356 (2000): 738–739.

<sup>56</sup> Żądzińska et. al., "Can Economic Stress," Żądzińska et. al., "Zastosowanie modeli ARI-MA."

<sup>57</sup> Piet Hein Jongbloet, Nel Roeleveld, Hans Groenewoud, "Where the Boys Aren't: Dioxin and the Sex Ratio," *Environmental Health Perspectives* 110 (2002): 1–3; Paolo Mocarelli et. al., "Paternal Concentrations of Dioxin and Sex Ratio of Offspring," *The Lancet* 355 (2000): 1858–1863.

<sup>58</sup> Irene Figà-Talamanca et. al., "Environmental Factors and the Proportion of Males at Birth in Italy," *Environmental and Occupational Health* 58 (2003): 119–124; Terttu Vartiainen, Leena Kartovaara, Jouko Tuomisto, "Environmental Chemicals and Changes in Sex Ratio: Analysis over 250 Years in Finland," *Environmental Health Perspectives* 107 (1999): 813–815.

<sup>59</sup> Eugene Pergament, Pinar Bayrak Todydemir, Morris Fiddler, "Sex Ratio: A Biological Perspective of 'Sex and the City,'" *Reproductive BioMedicine Online* 5 (2002): 43–46.

<sup>60</sup> Miroslav Peterka, Renata Peterkova, Zbynek Likovsky, "Chernobyl: Prenatal Loss of Four Hundred Male Fetuses in the Czech Republic," *Reproductive Toxicology* 18 (2004): 75–79.

and alcohol.<sup>61</sup> Sources of environmental stress are also seen in natural disasters, such as earthquakes<sup>62</sup> and floods,<sup>63</sup> and also in terrorist attacks,<sup>64</sup> wars<sup>65</sup> and economic crises.<sup>66</sup> Human populations respond to adverse environmental conditions by a decline of the number of boys at births, which is evident as a decrease of the sex ratio at birth.<sup>67</sup>

In 1973 Trivers and Willard<sup>68</sup> claimed that during a time of *prosperity* parents invest more resources such as food and care in boys, while in more difficult times, in girls. Their so-called *economic stress hypothesis* is based on the statement that during a time of *prosperity* natural selection favors mothers who bear male fetuses because they are not under any strong stress and ultimately, they give birth to sons. In a situation of economic stress, the opposite is observed: stress weakens the mother's biological condition, and she gives birth to daughters more often than to boys. Economic stress can be caused by reducing consumption below the expected demand which in turn leads to a decrease in the male-to-female proportion at birth.<sup>69</sup> The literature has confirmed that stress induced by acute economic

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<sup>61</sup> Elżbieta Żądzińska, "Fluctuating Asymmetry of Some Head Structures and Its Possible Causes," *Anthropological Review* 66 (2003): 39–54; Żądzińska et al., "Zastosowanie modeli ARIMA"; Christopher R.S. Dougherty, A.D. Jones, "The Determinants of Birth Weight," *American Journal of Obstetrics and Gynecology* 144 (1982): 190–200.

<sup>62</sup> Torche, Kleinhaus, "Prenatal Stress"; Misao Fukuda et al., "Decline in Sex Ratio at Birth after Kobe Earthquake," *Human Reproduction* 13 (1998): 2321–2322.

<sup>63</sup> Catalano, "Sex Ratios."

<sup>64</sup> Tim Bruckner, Ralph Catalano, Jennifer Ahern, "Male Fetal Loss in the U.S. Following the Terrorist Attacks of September 11, 2001," *BMC Public Health* 10 (2010): 273.

<sup>65</sup> Jan Graffelman, Rolf Hoekstra, "A Statistical Analysis of the Effect of Warfare on the Human Secondary Sex Ratio," *Human Biology* 72 (2000): 433–445; Piet Hein Jongbloet et al., "The Secular Trends in Male: Female Ratio at Birth in Post-war Industrialized Countries," *Environmental Health Perspectives* 109 (2001): 749–752; Ariane Kemkes, "Secondary Sex Ratio Variation during Stressful Times: The Impact of the French Revolutionary Wars on a German Parish (1787–1802)," *American Journal of Human Biology* 8 (2006), 6: 806–821; Liczbińska, Kralik, "Body Size"; O. Polasek et al., "Sex Ratio at Birth and War in Croatia (1991–1995)," *Human Reproduction* 20 (2005), 9: 2489–2491; Vartiainen, Kartovaara, Tuomisto, "Environmental Chemicals and Changes"; Branko Zorn et al., "Decline in Sex Ratio."

<sup>66</sup> Catalano, "Sex Ratios"; Victor Grech, "Historic Royal Events and the Male to Female Ratio at Birth in the United Kingdom," *European Journal of Obstetrics & Gynecology and Reproductive Biology* 191 (2015): 57–61; Victor Grech, "The Secondary Sex Ratio at Birth Was Depressed in Quebec in the Sovereignty Referendums," *Journal of Obstetrics and Gynaecology Canada* 37 (2015), 5: 405–411; John Jarrell, "Rationale for Study of the Human Sex Ratio in Population Studies of Polluted Environments," *Cadernos de Saude Publica* 18 (2002): 429–443; Żądzińska et al., "Can Economic Stress"; Żądzińska et al., "Zastosowanie modeli ARIMA."

<sup>67</sup> Żądzińska et al., "Can Economic Stress"; Żądzińska et al., "Zastosowanie modeli ARIMA."

<sup>68</sup> Robert L. Trivers, Dan E. Willard, "Natural Selection of Parental Ability to Vary the Sex Ratio of Offspring," *Science* 179 (1973): 90–92.

<sup>69</sup> Victor Grech, "The Influence of Migration on Secular Trends in Sex Ratios at Birth in Cuba in the past Fifty Years," *Western Indian Medical Journal* 63 (2014): 372e6.



reasons reduces the human sex ratio at birth. Catalano<sup>70</sup> showed changes in the SRB after the economic collapse following Germany's reunification. In East Germany in 1991, the male-to-female ratio at birth was at the lowest level since the end of WWII. Catalano<sup>71</sup> justified his results with economic indicators in the light of which in 1991, East German industrial production dropped by half to its lowest recorded value, 20% of the labor force was unemployed and another 20% worked a few hours a week. A sharp decline in M / F at birth was observed in Ireland as the response to the 2007 economic shock.<sup>72</sup> An improvement in economic and social conditions in OECD countries, especially in Estonia, is by contrast connected to an increase in the SRB in these countries.<sup>73</sup> Koziel and Ulijaszek<sup>74</sup> found partial evidence of greater investment in female offspring in families with the lowest level of paternal education and greater investment in male ones in the case of parents with higher levels of education. Mealey and Mackey<sup>75</sup> suggest that the sex ratio at birth in 19th-century Mormons was affected by the mother's social status and her access to resources. Ruckstuhl and her team<sup>76</sup> proved that women doing work categorized as "high stress" were more likely to give birth to daughters, while those with jobs categorized as "low stress" produced a similar number of daughters and sons or slightly more male offspring. Elissa Cameron and Fredrik Dalerum<sup>77</sup> investigated a group of the wealthiest people in the world<sup>78</sup> and showed that in billionaire families more sons than daughters were born compared to the general population.

In the population of the Province of Poznań, single motherhood increased the chance that the proportion of boys to girls at birth would decline. Marital status is considered one of the markers of socio-economic status, encompassing a complex

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<sup>70</sup> Catalano, "Sex Ratios," 1972–1975.

<sup>71</sup> Catalano, "Sex Ratios," after: Manfred J.M. Neumann, *German Unification: Economic Problems and Consequences*. Working Paper DP584 (London: Center for Economic Policy Research, 1991); Michael Funke, Jörg Rahn, "How Efficient Is the East German Economy? An Exploration with Microdata," *Economics of Transition* 10 (2002): 201–205.

<sup>72</sup> Victor Grech, "Economic Stress and the Secondary Sex Ratio: Ireland, Iceland, Greece and Latvia," *International Journal of Tropical Disease & Health* 5 (2015): 252–259.

<sup>73</sup> Ohto Kanninen, Aleks Karhula, "Changes in Income at Macro Level Predict Sex Ratio at Birth in OECD Countries," *PLoS ONE* (2016), DOI:10.1371/journal.pone.0158943.

<sup>74</sup> Sławomir Koziel, Stanley J. Ulijaszek, "Waiting for Trivers and Willard: Do the Rich Really Favor Sons?" *American Journal of Physical Anthropology* 115 (2001): 71–79.

<sup>75</sup> Mealey, Mackey, "Variation."

<sup>76</sup> Kathreen E. Ruckstuhl, Grant P. Colijn, Volodymyr Amiot, Erin Vinish, "Mother's Occupation and Sex Ratio at Birth," *BMC Public Health* 10 (2010): 269.

<sup>77</sup> Elissa Z. Cameron, Fredrik Dalerum, "A Trivers-Willard Effect in Contemporary Humans: Male-Biased Sex Ratios among Billionaires," *PLoS ONE* 4 (2009), 1: e4195, DOI: 10.1371/journal.pone.0004195.

<sup>78</sup> Elissa Cameron and Fredrik Dalerum built their dataset on the basis of information from the Forbes billionaire list.

of factors associated with a woman's social and professional position, her living conditions, and relationship with a social group such as social stigmatization, lack of psychological support, etc. This has been confirmed by studies of historical populations.<sup>79</sup> Unwed mothers mainly belonged to lower social classes. Among upper- and middle-class women, cases of illegitimate births were very rare.<sup>80</sup> Unmarried mothers and their children were treated more severely than married mothers and children born in wedlock. Illegitimate children were usually deprived of the right of succession, had no access to office jobs or the priesthood, and were sometimes stigmatized for life by the local community. It sometimes happened that the mothers of children born out of wedlock were relegated to a special place in the church called "the whore's pew" or "the pew of shame".<sup>81</sup> Access to medical care for single mothers was worse than for married women, which was associated with higher rates of death in their infants compared to the children of married couples<sup>82</sup>. Cases of infanticide were also frequent. As written by Revuelta-Eugercios,<sup>83</sup> "increased mortality among illegitimate children in the regular population was caused by shame, poverty, or a combination of both. Single women with no partner to support them economically or emotionally experienced great distress during pregnancy and after delivery, which could have harmful effects on children's health."<sup>84</sup> In the contemporary world, similarly to historical times, unmarried mothers more frequently belong to the category of women with low socioeconomic status than married ones. This makes them more exposed to the stress resulting from poor living conditions, unemployment and financial problems, and they more frequently experience adverse interpersonal factors such

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<sup>79</sup> Anders Brändström, "Illegitimacy and Lone-Parenthood in 19th Century Sweden," *Annales de démographie historique* 2 (1998): 93–114; Antoinette Fauve-Chamoux, "Continuity and Change among the Rhemish Proletariat: Preindustrial Textile Work in the Family Perspective," *The History of the Family* 6 (2001), 2: 167–187; eadem, *Domestic Service and the Formation of European Identity: Understanding the Globalization of Domestic Work, 16th-21st Centuries* (Bern: Peter Lang, 2004); Alice Reid et al., "Vulnerability among Illegitimate Children in Nineteenth Century Scotland," *Annales de démographie historique* 111 (2006): 89–113; Reto Schumacher, Grażyna Ryczkowska, Olivier Perroux, "Unwed Mothers in the City. Illegitimate Fertility in 19th-Century Geneva," *The History of the Family* 12 (2007), 3: 189–202.

<sup>80</sup> Schumacher, Ryczkowska, Perroux, "Unwed Mothers."

<sup>81</sup> Freddy Sarg, *En Alsace, du berceau à la tombe: rites, coutumes et croyances, hier et aujourd'hui* (Strasbourg: Editions Oberlin, 1977).

<sup>82</sup> Jan Kok, Frans van Poppel, Ellen Kruse, "Mortality among Illegitimate Children in Mid-nineteenth Century the Hague," in: *The Decline of Infant and Child Mortality. The European Experience: 1750–1990*, eds. Carlo A. Corsini, Paulo Viazzo (Den Haag: Martinus Nijhoff Publishers, 1997), 193–212.

<sup>83</sup> Bárbara A. Revuelta-Eugercios, "Abandoned and Illegitimate, a Double Mortality Penalty? Mortality of Illegitimate Infants in the Foundling Hospital of Madrid, La Inclusa (1890–1935)," *The History of the Family* 18 (2013): 44–67.

<sup>84</sup> Revuelta-Eugercios, "Abandoned and Illegitimate," 45.

as violence. They are also deprived of psychosocial support and social stability.<sup>85</sup> Unmarried status is still considered an important stress factor for pregnant women, translating into higher rates of preterm delivery and prevalence of low birth weight in subjects born at term compared with babies born to married mothers.<sup>86</sup>

Cities also increased the chance that the proportion of boys to girls at birth would decline below the biological norm. Cities destined single mothers to anonymity, which could protect them from the widespread social disapproval of illegitimate children at the time. In practice, single mothers were exposed more frequently to economic insecurity in cities than in rural areas. They were affected by low income, poverty and poor housing conditions, physical effort related to work, spatial mobility, and moreover stress caused by social disintegration.<sup>87</sup> Moreover, urban centers in the Province of Poznań were characterized by deficits in infrastructure, poor sanitary and hygienic conditions and a lack of access to clean water. Among them, the city of Poznań stood out in particular. With its dramatically poor living conditions – with a mainly working-class population concentrated in overcrowded districts – it posed a threat to human health and life.<sup>88</sup> The population's poor biological condition resulting mainly from very high infant and child death rates has frequently been highlighted in the literature. By contrast, rural areas still enjoyed an unpolluted natural environment.<sup>89</sup> Along with the poor living conditions of the city residents, the working conditions deteriorated. For example, in many Poznań factories and workshops, the working day lengthened from 12 hours to 16 hours. Health and safety in industrial plants left much to be desired. Factories and workshops failed to install protective devices, thus causing an increase in the number of workplace accidents. Poor living conditions and malnutrition were additionally to blame for the deteriorating health of employees: in 1900 nearly 45% of the Poznań population lived in one-room dwellings, often

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<sup>85</sup> Sheryl Thorburn Bird et al., "Beyond Marital Status: Relationship Type and Duration and the Risk of Low Birth Weight," *Family Planning Perspectives* 32 (2000): 281–287; Emily E Campbell, Jamie A. Seabrook, "The Influence of Socioeconomic Status on Adverse Birth Outcomes," *Canadian Journal of Midwifery Research and Practice* 15 (2016): 10–20; Jamie A. Seabrook, William R. Avison, "Family Structure and Children's Socio-Economic Attainment: A Canadian Sample," *Canadian Review of Sociology* 52 (2012): 66–88.

<sup>86</sup> Sylvia Kirchengast, Michael Mayer, Manfred Voigt, "Pregnancy Outcome Is Associated with Maternal Marital Status in Austria – Even at the Beginning of the 21st Century," *Anthropologischer Anzeiger* 65 (2007): 415–426.

<sup>87</sup> Reid et al., "Vulnerability."

<sup>88</sup> Budnik, Liczbińska, "Urban and Rural Differences"; Liczbińska, "Diseases"; eadem, *Lutherans*; eadem, *Umieralność*; eadem, "Infant and Child Mortality among Catholics and Lutherans in Nineteenth Century Poznań", *Journal of Biosocial Science* 41 (2009): 661–683.

<sup>89</sup> Budnik, Liczbińska, "Urban and Rural Differences"; Liczbińska, "Diseases"; eadem, *Lutherans*; eadem, *Umieralność*; eadem, "Infant."

cramped, damp and unheated, one room sometimes shared by 5 to 12 people.<sup>90</sup> Poverty, the low standard of living, the effort related to performing physical work and stress affected pregnant women through the biological (physiological) mechanisms and could have had a negative effect on the course of pregnancy and translated into the more frequent elimination of weaker male fetuses, preterm births (causing perinatal death) or the stillbirths of males rather than females. Moreover, in the Province of Poznań of the second half of the 19th and early 20th centuries, there were clear differences in the rates of illegitimate births depending on the size of the place of residence: the highest figures were noted in cities and towns while the lowest were in the villages of the region.<sup>91</sup> As was mentioned earlier in this paper, this fact could have additionally contributed to the proportion of boys to girls at birth being lower in cities than in rural areas.

### Research limitations

We are aware that our research is not free from limitations. The aggregate data did not allow a deeper insight into the phenomenon under study, which would have been done if individual information on births had been used. Secondly, the aggregate data on live births by sex did not contain information on the duration of pregnancy, including pre-term and prolonged pregnancies. Moreover, the lack of information on fetal deaths in utero, miscarriages / abortions and stillbirths as well as maternal age at birth and birth order did not allow us to capture the biological factors driving the changes of the SRB in the period under study. It is worth emphasizing that the variability of the SRB values obtained in this work could also be due to other factors which have not been identified here.

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<sup>90</sup> Czesław Łuczak, *Życie gospodarczo-społeczne w Poznaniu 1815–1918* (Poznań: Wydawnictwo Poznańskie, 1965).

<sup>91</sup> Liczbińska, *Lutherans*, 113.

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## **Did the Sex Ratio at Birth Reflect Social and Economic Inequalities? A Pilot Study from the Province of Poznań, 1875–1913**

### **Summary**

The sex ratio at birth, or SRB (secondary sex ratio or the masculinization rate of newborns), is a simple test of the reliability of historical sources. According to biological law its range is 105–107 of males born alive per 100 female live births. There are studies suggesting that SRB values could be modified by environmental stress which, when it affects pregnant women, leads to greater elimination of weaker male fetuses. The goal of this study was to check whether and to what extent the values of sex ratio at birth may have reflected social and economic inequalities in the Province of Poznań (German: *Provinz Posen*) in the late 1800s and early 1900s. It was assumed that maternal economic, social and emotional well-being differed according to the size of the place of residence (Poznań-town-village) and marital status (married-unmarried). Adverse living conditions affecting pregnant women could have translated into perinatal outcomes, including the decline of the number of boys to girls at birth. The study was based on aggregate data encompassing the numbers of live births for the years 1875–1913. They were derived from Prussian statistical yearbooks. In total 2,249,039 aggregate numbers of live births were collected, including 1,154,199 live-born males and 1,094,840 live-born females. The specificity of the Prussian statistics allowed maternal socio-economic variables, i.e., the mother's place of residence and her marital status to be taken into account. The chi-square test showed that the SRB in the range of the biological norm was most frequent in rural areas and among married mothers, while it was least frequent in Poznań and among unmarried mothers. In the Province of Poznań, living in urban areas (e.g., Poznań) and single motherhood were the predictors increasing the chance that the proportion of boys to girls at birth would decline below the biological norm. These factors could affect women during pregnancy through biological (physiological) mechanisms induced by adverse economic conditions (poverty, poor housing conditions, physical effort related to work and spatial mobility) and psychological stress (a lack of social approval and support, social instability, occurrence of stigmatization etc.). It is worth noting, however, that the variability of the values of sex ratio at birth could also be due to other factors, not identified (captured) in this paper.

### **Czy wskaźnik proporcji płci przy urodzeniu odzwierciedlał nierówności społeczne i ekonomiczne? Pilotażowe badania prowincji poznańskiej, 1875–1913**

#### **Streszczenie**

Proporcja płci w momencie urodzenia (współczynnik wtórnej proporcji płci lub wskaźnik maskulinizacji noworodków) jest prostym testem wiarygodności źródeł historycznych i zgodnie z prawem biologicznym zawiera się w przedziale 105–107 żywo urodzonych noworodków płci męskiej na 100 urodzeń płci żeńskiej. Istnieją badania sugerujące,



że wartość wskaźnika proporcji płci przy urodzeniu może być modyfikowana przez stres środowiskowy, który działając na kobiety w ciąży, prowadzi do częstszej eliminacji słabszych płodów płci męskiej. Celem pracy było sprawdzenie, czy i w jakim stopniu wartości wskaźnika wtórnej proporcji płci mogły odzwierciedlać nierówności społeczne w prowincji poznańskiej w ostatnich dekadach XIX i początku XX wieku. W pracy założono, że ekonomiczny, społeczny i emocjonalny dobrostan matki różnił się ze względu na wielkość miejsca zamieszkania (Poznań / miasteczko / wieś) oraz stan cywilny (kobiety niezamężne / mężatki). Niekorzystne warunki życia kobiet w ciąży mogły przekładać się na wyniki okołoporodowe, w tym spadek liczby urodzeń chłopców do dziewczynek. Badania oparto na zbiorczych danych obejmujących liczby urodzeń żywych w latach 1875–1913. Pochodzą one z pruskich roczników statystycznych. Ogółem zebrano 2 249 039 liczb urodzeń żywych, w tym 1 154 199 noworodków płci męskiej i 1 094 840 płci żeńskiej. Specyfika pruskich statystyk pozwoliła uwzględnić matczyne zmienne społeczno-ekonomiczne, tj. miejsce zamieszkania matki i jej stan cywilny. Test chi-kwadrat wykazał, że na obszarach wiejskich i w grupie matek zamężnych wartość wskaźnika proporcji płci kształtowała się najczęściej w zakresie normy biologicznej, podczas gdy w Poznaniu i w grupie matek niezamężnych – najrzadziej. W populacji zamieszkującej prowincję poznańską obszary miejskie (np. Poznań) i samotne macierzyństwo były predyktorami zwiększającymi szansę na spadek proporcji chłopców do dziewczynek przy urodzeniu. Czynniki te mogły działać na kobiety w ciąży poprzez mechanizmy biologiczne (fizjologiczne) indukowane niekorzystnymi warunkami ekonomicznymi (ubóstwo, złe warunki mieszkaniowe, wysiłek fizyczny związany z pracą, mobilność przestrzenna) i stresem psychologicznym (brak aprobaty i wsparcia społecznego, niestabilność społeczna, stygmatyzacja itp.). Warto podkreślić, że zmienność wskaźnika proporcji płci mogła wynikać również z innych czynników, które w tej pracy nie zostały zidentyfikowane (uchwycone).