

Distribution of orthognathic surgery among the Swedish population: a retrospective register-based study

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ABSTRACT

Objective: The aim of this study was to provide a nationally representative assessment of orthognathic procedures performed in hospitalised patients in Sweden and study regional differences in prevalence, demographic parameters and hospitalisation time.

Material and methods: From the Swedish National Board of Health and Welfare's register, all the patients undergoing orthognathic surgery between 2010 and 2014 were identified. Outcome variables were categorised into: (1) Surgical methods and regional distribution (2) Demographic variations (3) Hospitalisation time.

Results: The population-prevalence-rate of orthognathic procedures over the 5-year period was 6.3 (*SD* 0.4) per 100,000 persons, a regional difference in the prevalence was found. Most common were Le Fort I osteotomies (43.4%) and bilateral sagittal split osteotomies (41.6%), 39% of the patients had bimaxillary surgery. The majority of the surgery was performed in the age group 19–29 (68.8%). The mean hospital stay was 2.2 days (*SD* = 0.9, range 1.7–3.4). A significant regional difference ($p \leq 0.001$) was found in hospitalisation time for single-jaw versus bimaxillary surgery.

Conclusions: Regional differences in the distribution of orthognathic surgery and demographic variations were found in Sweden in 2010–2014. The underlying causes of variations are still unknown and request further investigation.

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Introduction

Correction of dentofacial anomalies is one of the most common surgical procedures at maxillofacial units worldwide. The aim is to restore oral function and facial aesthetics [1,2], as well as to improve the patients' quality of life [3–5]. As the traditions in treatment selection and source of treatment funding vary internationally, it is difficult to estimate and compare the need for orthognathic surgery.

Little has been published about the exact prevalence of orthognathic surgery worldwide. Approximately 2% of the population in the United States have a malocclusion or facial deformity that might benefit from orthognathic surgery [6]. In Denmark 1000 orthognathic procedures were performed in 2015, corresponding to approximately 0.02% of the Danish population [7]. The underlying causes of these variations are still unknown. Different health care systems for financing orthodontic treatment and orthognathic surgery influence the number of treated patients in a population but also cause differences in the procedures of the treatment. Previous studies have shown a reduction in the number of orthognathic surgeries performed due to inhabitants'

inability to get medical insurance and Medicaid coverage, especially in the United States [8–10].

Swedish health care is largely government-funded [11]. Twenty-one regional councils are responsible for hospitals and primary care centres, providing health care for approximately ten million inhabitants. The regions are merged into six geographic health care regions. Generally, all orthognathic treatment is performed in the public sector. Surgical treatment of dentofacial deformities is performed at 25 maxillofacial units/hospitals in those six health regions.

Several studies have shown that maxillofacial skeletal deformities often result in a non-functional occlusion, impaired psychosocial and aesthetic well-being of patients [1,12,13]. According to the Swedish National Board of Health the indications for orthognathic surgery need to be either a skeletal disproportion resulting in a facial disfigurement, or a functional problem not possible to treat with only orthodontics.

Normally, patients in Sweden with occlusal and/or dentofacial discrepancies are referred to an orthodontist for judgement of treatment need and for treatment planning. As there is no index used to define the treatment need for orthognathic surgery, indications vary between regions. The

absence of a nationally used index entails that resource issues as well as the judgement of single surgeons might determine the decision for surgery.

In a questionnaire from 2011, Andrup et al. presented an incidence of nine orthognathic procedures per 100,000 individuals in Sweden, with a large spread in the regional distribution [14].

To our knowledge, there are no more cross-sectional studies on the surgical treatment of patients with dentofacial deformities in Sweden. We wanted to obtain a more precise estimate of this population by using the National Board of Health and Welfare's register (NBHR).

The open data from the NBHR indicate the rate of orthognathic surgery has a large spread over time. As this study covers a 5-year period, the results become more representative.

The aim of the present study was to provide a nationally representative estimate of the number and type of different orthognathic procedures performed in hospitalised patients in Sweden. In addition, we also wanted to study the demographic variations and hospitalisation/length of stay (LOS). Are there any regional differences in prevalence, demographic parameters and hospitalisation time in Sweden?

Materials and methods

Study design and sample size

This is a cross-sectional retrospective study assessing the prevalence of orthognathic surgery among the whole Sweden population during 5 years (2010–2014).

The National Board of Health and Welfare in Sweden collects and develops statistics for health care, medical care and social services. We used the National Board of Health and Welfare's register (NBHR) to identify all the patients with dentofacial deformities who underwent Orthognathic surgery between 1 January 2010 and 31 December 2014. The NBHR collected data from the maxillofacial units/hospitals in Sweden (Figure 1). This register comprises records on health care episodes in inpatient (hospitalised) and outpatient specialist care. All surgeons record the diagnosis for each dentofacial anomaly by using the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), (K07.0 major anomalies of the jaw size, K07.1 anomalies of jaw-cranial base relationship, K07.2 anomalies of dental arch relationship and K07.3 anomalies of tooth position). The surgical procedures were coded according to the Nordic Medico-Statistical Committee (NOMESCO, version 1.15). We identified 3000 patients undergoing 4453 surgical procedures during 2010–2014.

Data collection and outcome variables

The Swedish National Board of Health and Welfare provided data with identified surgical procedures according to NOMESCO, including Sagittal ramus-osteotomy (EDC10), Vertical ramus-osteotomy (EDC15), Genioplasty (EDC30), Segmental osteotomy of the maxilla (EEC00) and Le Fort I

-osteotomy (EEC05) in 2010–2014. For each region with associated hospitals, the number of orthognathic surgeries, type of orthognathic procedures, diagnosis of the dentofacial anomalies, indication for surgery, length of stay, age at the time of surgery, gender and complications identified during the hospital stay were recorded. The data was collected for a 5-year period as there are large fluctuations in the number of operated patients in between different years. The data was then sorted into three categories: (1) Surgical methods and regional distribution, (2) Demographic variations, and (3) Hospitalisation time.

Patients 15 years of age and older with diagnosis criteria of K070–K073 who underwent orthognathic procedures (EDC10, EDC15, EDC30, EEC00, EEC05) between 2010 and 2014 were included. Patients who underwent orthognathic surgery due to facial trauma or for the removal of cysts or tumours were excluded as we aimed to study elective orthognathic surgery. Patients who were operated on at two different occasions were also excluded, as it was impossible to identify if the repeated surgery was caused by stepwise surgery or reoperation, except when length of stay was calculated.

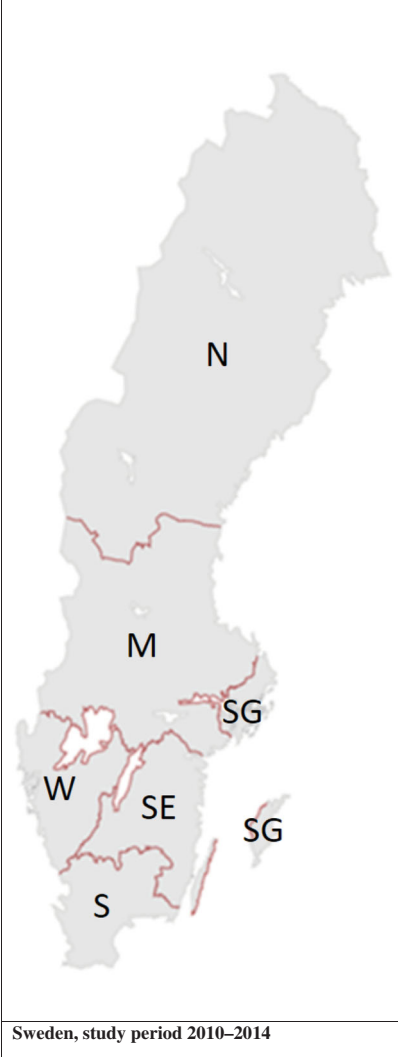
No patients could be identified in the dataset since it was anonymized before delivery. This study was approved by the Regional Ethical Board in Linköping (2017/242-32).

Selection and distribution bias

In this register-based study we investigate whether there are any regional differences in prevalence, demography or hospitalisation time for those patients who underwent orthognathic procedures in Sweden. The surgery was performed at 25 hospitals in six health care regions. However, two hospitals failed to register all surgical data during the study period (Figure 1). Some patients underwent surgery in a region other than their associated county/region. To avoid this selection bias, adjustment was made regarding the study population by contacting the concerned hospital. The population adjustment was performed for Kronoberg county, Blekinge county and Halland county.

Statistical analysis

The set of data from the Swedish NBHR was received as a large, encrypted text file and transferred to an Excel file for further statistical analysis with the help of SPSS software. An experienced statistician was consulted for the statistical analyses. A Pearson Chi-Square Test was used for testing significance between gender and regions. An independent *T*-test was used to calculate a significant difference between gender and the hospitalisation time. The one-way analysis of variance (ANOVA) was used to determine whether there are any statistically significant differences between the six health regions in Sweden. Finally, a post-hoc test (Games Howell) was used to compare combinations of groups.



| Region | Population* | Hospitals with Maxillofacial Units and the number of patients |
|--------------------------------|-------------|---------------------------------------------------------------|
| The Northern Region (N) | 898 656 | Norrlands Universitetssjukhus 129 |
| | | Sunderby sjukhus 101 |
| | | Sundsvalls sjukhus 39 |
| | | Östersunds sjukhus 18 |
| The Middle Swedish Region (M) | 2 127 835 | Akademiska sjukhuset 41 |
| | | Falu lasarett 35 |
| | | Gävle sjukhus 132 |
| | | Karlstads sjukhus 12 |
| | | Mälarsjukhuset 63 |
| | | Universitetssjukhuset Örebro 65 |
| The Stockholm Region (SG) | 2 450 029 | Västerås lasarett 8 *** |
| | | Huddinge sjukhus 209 |
| | | Karolinska sjukhuset 357 |
| | | Södersjukhuset 2 |
| The Western Region (W) | 1 929 523 | Visby lasarett 28 |
| | | NU-sjukvården 133 |
| | | Mölnadalssjukhus - ** |
| | | Sahlgrenska universitetssjukhuset 172 |
| | | Skaraborgs sjukhus 130 |
| The Southeastern Region (SE) | 1 077 837 | Södra Älvsborgs sjukhus 95 |
| | | Ryhov länsjukhus 173 |
| | | Universitetssjukhuset i Linköping 153 |
| The Southern Region (S) | 1 889 345 | Hallands sjukhus Halmstad 198 |
| | | Helsingborgs lasarett 242 |
| | | Universitetssjukhuset i Lund 465 |
| Sweden, study period 2010–2014 | Total | 10 373 134 25 Hospitals 3000 |

Figure 1. Health care regions and associated maxillofacial units in Sweden. *Source: "Folkmängd i riket, län och kommuner 30 september 2020". Statistiska centralbyrån. (Datauttag i November 2020.) **Data is missing for Mölnadalssjukhus, ***data is partly missing for Västerås Hospital.

Table 1. The prevalence orthognathic surgery in the six health care regions.

| Regions | Years | | | | | Total | Number of patients/ 100,000 inhabitants. | |
|---------|-------|------|------|------|------|-------|---------------------------------------------|--------|
| | 2010 | 2011 | 2012 | 2013 | 2014 | | Mean | |
| N | 61 | 41 | 60 | 70 | 55 | 287 | 6.5 (SD 1.2) | 0.425 |
| M | 86 | 88 | 59 | 63 | 60 | 356 | 3.6 (SD 0.7) | 0.001* |
| SG | 119 | 116 | 117 | 136 | 108 | 596 | 5.5 (SD 0.5) | 0.018* |
| SE | 63 | 68 | 77 | 69 | 49 | 326 | 5.3 (SD 0.8) | 0.140 |
| W | 101 | 116 | 105 | 101 | 107 | 530 | 6.6 (SD 0.4) | 0.734 |
| S | 211 | 184 | 165 | 173 | 172 | 905 | 10.7 (SD 1.1) | 0.001* |
| Total | 641 | 613 | 583 | 612 | 551 | 3000 | 6.3 (SD 0.4) | – |

N: Northern Region, M: Middle Swedish Region, SG: Stockholm Region, SE: South-eastern Region, W: Western Region and S: Southern Region.

*One sample *t*-test, statistic is significant at the 0.05 level.

Results

Surgical methods and regional distribution

Between 2010 and 2014, a total of 3000 patients (4453 orthognathic procedures) were reported to the NBHR in Sweden (Table 1). In this register-based study we found data from all six health care regions, including associated hospitals (Figure 1). During the studied period of time, there was missing data from Mölnadalssjukhus in the Western region

(W) and partially missing data from Västerås hospital in the Middle-Swedish region. The average prevalence rate of orthognathic procedures over the 5-year study period was 6.3 per 100,000 persons (Table 1). The Southern region had the highest prevalence rate of orthognathic procedures per 100,000 persons (10.7). A low prevalence rate was observed in the Middle-Swedish region (3.6). The frequencies of orthognathic surgical procedures performed in the six health care regions are shown in Table 2. The most common orthognathic surgical methods were Le Fort I osteotomy (43.4%/1997 patients) and sagittal split osteotomy (41.6%/1897 patients), 1184 of the patients (39.4%) had bimaxillary surgery. Genioplasty was most common in the Southern region and the highest rate of segmental osteotomies in the maxilla was reported from the Western region (Table 2).

Demographic variations

In total, 3000 patients, 1383 male and 1617 female with mean age of 22 years (range 15–74) underwent orthognathic surgery during the study period. 3072 surgical procedures

Table 2. Demographic variations: age and prevalence of orthognathic surgical methods in six regions.

| Regions | N | | | | M | | | | SG | | | | SE | | | | W | | | | S | | | | Total |
|---------------------------------------------------------|----------|-----|-----|-----|-----|-----|----|----|----------|-----|-----|----|----------|-----|----|----|-------|------|----|----|----------|-----|----|----|---------------------|
| | a | b | c | d | a | b | c | d | a | b | c | d | a | b | c | d | a | b | c | d | a | b | c | d | |
| Age groups | | | | | | | | | | | | | | | | | | | | | | | | | Surgical procedures |
| EDC10 SSO | 18 | 124 | 4 | 8 | 34 | 163 | 12 | 8 | 101 | 194 | 36 | 16 | 42 | 200 | 14 | 11 | 94 | 230 | 18 | 8 | 161 | 356 | 32 | 13 | 1897 |
| | 11% | 79% | 4% | 5% | 16% | 75% | 6% | 4% | 29% | 56% | 10% | 5% | 16% | 75% | 5% | 4% | 27% | 66% | 5% | 2% | 29% | 63% | 6% | 2% | |
| EDC15 VRO | 2 | 27 | 0 | 1 | 3 | 7 | 0 | 0 | 22 | 43 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 10 | 60 | 5 | 1 | 192 |
| | 7% | 90% | 0% | 3% | 30% | 70% | 0% | 0% | 30% | 59% | 11% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 13% | 80% | 6% | 1% | |
| EDC30 GP | 0 | 7 | 1 | 2 | 6 | 18 | 3 | 0 | 5 | 21 | 7 | 2 | 3 | 20 | 0 | 1 | 12 | 20 | 1 | 3 | 26 | 68 | 7 | 1 | 234 |
| | 0% | 70% | 10% | 20% | 22% | 67% | 1% | 0% | 14% | 60% | 20% | 6% | 13% | 83% | 0% | 4% | 33% | 56% | 3% | 8% | 25% | 67% | 7% | 1% | |
| EEC00 MSO | 6 | 40 | 5 | 2 | 10 | 8 | 0 | 1 | 5 | 11 | 3 | 1 | 2 | 10 | 1 | 1 | 25 | 57 | 2 | 4 | 15 | 37 | 3 | 2 | 253 |
| | 11% | 75% | 19% | 4% | 53% | 42% | 0% | 5% | 25% | 55% | 15% | 5% | 14% | 71% | 7% | 7% | 28% | 65% | 2% | 4% | 26% | 66% | 5% | 3% | |
| EEC05 LF1 | 21 | 135 | 6 | 8 | 47 | 185 | 12 | 8 | 107 | 231 | 38 | 8 | 28 | 149 | 11 | 6 | 87 | 220 | 14 | 14 | 177 | 419 | 32 | 13 | 1977 |
| | 12% | 79% | 4% | 5% | 19% | 74% | 5% | 3% | 28% | 60% | 10% | 2% | 14% | 77% | 6% | 3% | 26% | 66% | 4% | 4% | 28% | 65% | 5% | 2% | |
| Total | 47 | 333 | 15 | 21 | 99 | 381 | 27 | 17 | 240 | 500 | 92 | 27 | 77 | 379 | 26 | 19 | 218 | 532 | 35 | 29 | 389 | 941 | 79 | 30 | 4553 |
| Comparisons of column proportions, <i>post-hoc</i> test | | | | | | | | | | | | | | | | | | | | | | | | | |
| Regions | N | | | | M | | | | SG | | | | SE | | | | W | | | | S | | | | |
| <18 years | - | | | | - | | | | N, SE | | | | - | | | | N, SE | | | | N, M, SE | | | | |
| 19–29 years | SG, W, S | | | | SG | | | | - | | | | SG, W, F | | | | - | | | | - | | | | |
| 30–40 years | - | | | | - | | | | SE, W, S | | | | - | | | | - | | | | - | | | | |
| >40 years | - | | | | - | | | | - | | | | - | | | | - | | | | - | | | | |

SSO: Sagittal Split Osteotomy (uni- or bilateral); VRO: Vertical Ramus Osteotomy; GP: Genioplasty; MSO: Maxillary Segmental Osteotomy; LF1: Le Fort I Osteotomy.

Post-hoc test (Games Howell), comparisons between the regions (statistic is significant at the 0.05 level only for marked regions).

N: Northern Region; M: Middle Swedish Region; SE: South-eastern Region; W: Western region; S: Southern Region.

Age groups a (<18 years), b (19–29 years), c (30–40 years) and d (>40 years).

were performed in the age group 19–29 year (68.8%), (Table 2). There are statistical differences between regions regarding age-groups and the number of surgical procedures. Table 2 shows that the most significant differences were found in age-groups a (<18 years) and b (19–29 years). Le Fort I osteotomy and bilateral sagittal split osteotomy were the most common surgical methods in all six regions (86.6%). Regional differences were also found in the youngest groups (a & b) for these orthognathic procedures. In total, 4453 orthognathic surgeries were performed, 2154 (47.3%) in male and 2399 (52.6%) in female (Table 3). There was no significant difference between health regions in Sweden regarding sex. Furthermore, no significant difference between the surgical methods in relation to sex was found (Table 3).

The diagnostic groups K070–K073 are so wide in indication that further analyse of those groups were in vain. The codes were only possible to use as a marker indicating orthognathic treatment, instead of for example K090, EDC10-code for removal of a large cyst.

Hospitalisation time

The mean hospitalisation time for all the patients who had orthognathic surgery was 2.2 days ($SD=0.9$, range 1.7–3.4), (Table 4). No significant difference between male and female was found ($p=.37$). The South-eastern region had the highest mean number of days of hospital stay, the Southern region and Stockholm region had the lowest mean length of hospital stay.

The differences in hospitalisation time for different orthognathic surgical procedures are shown in Table 5. The average hospitalisation time was 2.8 days (range, 1.7–3.5) following Le Fort I osteotomy ($n=1977$), 2.8 days (range, 1.7–3.5) following bilateral sagittal split osteotomy

($n=1897$). The mean hospitalisation time for all the procedures was estimated to be 2.5 ± 1.0 day (range, 1.7–2.8 days) when compared for each different surgical method, this analysis includes the bimaxillary cases once for each jaw. There are significant differences between the regions regarding the length of stay and surgical procedures (Table 5). The shortest hospitalisation time was registered for the Stockholm region and the Southern region (1.4 days and 1.6 days respectively). The longest hospitalisation was noted for the South-eastern region (3.4 days).

Patients with bimaxillary surgery stayed longer at hospital in comparison to patients who had single jaw surgery, (Table 6). A *post-hoc* test showed that there was a significant regional difference between the length of stay and the extent of surgery (single jaw surgery or bimaxillary surgery, $p<.001$, Table 6).

Discussion

This retrospective register-based study assessed the distribution of orthognathic surgeries performed in Sweden during a 5 year period (2010–2014). It is the first study with nationwide reliable data on the performed orthognathic surgeries in Sweden, as reported to the National Board of Health and Welfare. In Sweden, there is a long tradition of government requiring data concerning different fields of tax-funded public service. Due to an obligation to report data considering performed surgery, it is possible to find a reliable reference considering rate of orthognathic surgery. The Swedish population registry is one of the oldest worldwide, and has been continuous since 1686. By combining the registries, it was possible to provide a comprehensive estimate of the prevalence of orthognathic surgery based on gender, the type of the surgical procedures performed, and the length of hospital stay.

Table 3. Demographic variations: sex and prevalence of orthognathic surgeries in the six regions.

| Regions | N | | | | | | M | | | | | | SG | | | | | | SE | | | | | | W | | | | | | S | | | | | | Total | | | | | | Chi-Sq p= |
|-----------|-----|-------|-----|----|-------|--|-----|-------|-----|-----|-------|--|-----|-------|-----|-----|-------|--|-----|-------|-----|-----|-------|--|------|-------|------|-----|---------|------|-----|---------|------|-----|-------|--|-------|-------|--|------|------|--|--------------|
| | m | | | f | | | m | | | f | | | m | | | f | | | m | | | f | | | m | | | f | | | m | | | f | | | m | | | f | | | |
| | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | n | % | | | | | | | | |
| EDC10 SSO | 71 | (45%) | | 86 | (55%) | | 81 | (38%) | | 135 | (62%) | | 158 | (46%) | | 188 | (54%) | | 144 | (54%) | | 145 | (41%) | | 205 | (59%) | | 247 | (44%) | | 314 | (56%) | | 825 | (43%) | | 1072 | (57%) | | 1897 | 0.41 | | |
| EDC15 VRO | 17 | (7%) | | 13 | (90%) | | 3 | (30%) | | 7 | (70%) | | 33 | (45%) | | 40 | (55%) | | 0 | (0%) | | 3 | (60%) | | 2 | (40%) | | 34 | (46%) | | 40 | (54%) | | 90 | (47%) | | 102 | (53%) | | 192 | 0.60 | | |
| EDC30 GP | 3 | (30%) | | 7 | (70%) | | 14 | (52%) | | 13 | (48%) | | 15 | (43%) | | 20 | (57%) | | 17 | (71%) | | 13 | (36%) | | 23 | (64%) | | 55 | (54%) | | 47 | (46%) | | 107 | (46%) | | 127 | (54%) | | 234 | 0.14 | | |
| ECC00 MSO | 31 | (58%) | | 22 | (42%) | | 11 | (58%) | | 8 | (42%) | | 13 | (65%) | | 7 | (35%) | | 3 | (21%) | | 41 | (46%) | | 47 | (54%) | | 28 | (48%) | | 31 | (52%) | | 135 | (53%) | | 118 | (47%) | | 253 | 0.16 | | |
| ECC05 LFI | 90 | (53%) | | 80 | (47%) | | 114 | (45%) | | 139 | (55%) | | 218 | (57%) | | 166 | (43%) | | 99 | (51%) | | 164 | (49%) | | 171 | (51%) | | 316 | (49%) | | 325 | (51%) | | 997 | (50%) | | 980 | (50%) | | 1977 | 0.07 | | |
| Total | 212 | | 208 | | 223 | | 739 | | 421 | | 263 | | 236 | | 629 | | 449 | | 683 | | 759 | | 2154 | | 2399 | | 4553 | | (52.6%) | 2154 | | (47.3%) | 4553 | | 0.23 | | | | | | | | |

SSO: Sagittal Split Osteotomy (uni- or bilateral); VRO: Vertical Ramus Osteotomy; GP: Genioplasty; MSO: Maxillary Segmental Osteotomy; LFI: Le Fort I Osteotomy.
N: Northern Region; M: Middle Swedish Region; SE: South-eastern Region; W: Western region; S: Southern Region.

Pearson Chi-Square: no statistic significance, for none of the regions $p < 0.05$.

We found that the number of surgical procedures vary between regions, with a higher rate of operations in the Southern region. The reason for this difference is not fully understood. However, we speculate that it might have to do with different traditions in the judgement of indications for treatment. Accessibility to operating facilities offering general anaesthesia may also vary between regions. Orthognathic treatment was equally distributed between the sexes, both nationwide and regional. The two most common surgical methods were, as described in the results, Le Fort I osteotomy and bilateral sagittal split osteotomy, or a combination of these, which is in accordance with previous studies reviewed by Kjeraard [7].

We found that genioplasty was overrepresented in the southern region. There is a problem in the evaluation of the rate of genioplasties; this operation is frequently performed in private settings and thereby not reported to the NBHR. Only if there is an osteotomy the genioplasties are coded EDC30. In other words, silicon chin implants provided by plastic surgeons are not included in this survey.

In a study by Venugoplan et al. [15], the number and type of the orthognathic procedures performed on hospitalised patients were estimated in the United States 2008. The authors found that approximately 3 out of 100,000 individuals were subjected to orthognathic surgery with average age of 26.7 years [15].

In the present study, the mean age at operation was slightly lower, 21–23 years, which is similar to the mean age for orthognathic surgery (23.4 years) reported for Barcelona 2014 [16]. In the late 1990s, there were 23,000 patients discharged after orthognathic surgery in the United States [17], which is a considerably higher number compared to 2008. The low number of orthognathic procedures nowadays in the United States might be explained by the role of private insurance for case acceptance [17]. Moreover, around 1000 orthognathic treatment procedures (20 per 100,000 persons) were performed in Denmark in 2015 [7], which is more than twice as many per 100,000 persons as in Sweden and sevenfold more than in the US. The high number of cases in Denmark may be explained by orthognathic surgery being well established within the health care system.

In comparison to previous studies, Andrup et al. found 891 orthognathic surgery cases (9 per 100,000 individuals) in Sweden 2011 by using a questionnaire survey. A large spread in distribution between the clinics and the counties was observed by the authors [14]. In the present study, the overall prevalence rate of orthognathic procedures over the 5-year study period was 6.3 per 100,000 individuals. The Southern region had the highest prevalence rate of orthognathic procedures per 100,000 individuals (10.7), a low rate of orthognathic surgery was observed in the Middle Swedish region (3.6).

In Sweden, the Public Health Service take care of patients who need orthodontic treatment and orthognathic surgery. Around 25% of the patients up to 20 years of age fulfil the Swedish requirements for receiving orthodontic treatment free of charge [18,19]. The exact number of

patients with dentofacial deformities in need of surgical treatment is still unknown. It has been estimated, however, that approximately 5% of patients with severe cases of malocclusion such as overjet >7 mm or open-bite > 3 mm are subjected to orthognathic surgery [20].

The motivating reasons for orthognathic surgery are factors such as pain and malocclusion, although the majority of the studies also highlighted the aesthetic aspect as a main issue [21–24]. According to Swedish Healthcare Legislation, the indications for orthognathic surgery must be functional. The underlying causes of the regional variations found in rates of orthognathic surgery are unknown. However, one explanation might be the difficulty for professionals and surgeons to define the indication for orthognathic surgery. Potential factors include a lack of a standard reproducible examination method and differences in surgical training or tradition [25], but also the overlapping treatment possibilities

with acceptable treatment results for both orthodontic treatment and a combined orthodontic-surgical treatment [26–27]. There are several indices for the definition of orthodontic treatment need [28–30], and the IOFTN for determining the need for orthognathic surgery [31]. As far as we know, no indices are used for estimating or deciding the need of orthognathic surgery in Sweden.

Using a retrospective cohort study design, Huamán et al. estimated the hospital length of stay and identified factors associated with length of stay (LOS) in orthognathic surgery patients in the USA. Among orthognathic surgery patients, approximately 28% underwent isolated mandibular procedures (EDC10), 35% underwent isolated maxillary surgery (EEC05) and bimaxillary surgery was performed in 37% of cases [32]. Furthermore, the mean hospitalisation time for all procedures was 1.7 ± 1.2 days, for single jaw surgery 1.4 ± 0.7 days and for bimaxillary surgery 2.3 ± 1.6 days [32]. In the present study the mean LOS for all surgeries was 2.2 ± 0.9 day.

The number of performed surgeries 2011 presented by Anderup et al. [14] does not correspond to the numbers found in the registry of the National Board of Health for the same year. For 2011, Anderup et al. report a notable higher frequency of operated patients (891 patients) than reported to the National Board of Health Registry (NBHR) (732 patients). This inconsistency raises concern regarding the validity of their results and illustrates the difficulty in finding reliable data from a retrospective survey compared to data from a registry with continuous registration. Likewise, it is

Table 4. Hospitalisation time according to sex and health regions.

| Regions | Male | | | Female | | | Total | | |
|---------|------|-----------|-----|--------|-----------|-----|-------|-----------|-----|
| | Nr. | Mean/days | SD | Nr. | Mean/days | SD | Nr. | Mean/Days | SD |
| N | 142 | 2.2 | 0.8 | 145 | 2.1 | 0.9 | 287 | 2.1 | 0.9 |
| M | 150 | 2.2 | 1.2 | 206 | 2.2 | 1.2 | 356 | 2.5 | 1.2 |
| SG | 294 | 1.6* | 0.6 | 302 | 1.6* | 0.7 | 596 | 1.6 | 0.6 |
| SE | 148 | 3.2* | 0.9 | 178 | 3.4* | 1.0 | 326 | 3.3 | 1.0 |
| W | 235 | 2.2 | 1.0 | 295 | 2.3 | 1.0 | 530 | 2.3 | 1.0 |
| S | 414 | 1.7* | 0.7 | 491 | 1.6* | 0.8 | 905 | 1.7 | 0.8 |
| Total | 1383 | 2.02 | 1.0 | 1617 | 2.04 | 1.0 | 3000 | 2.1 | 0.9 |

*The Chi-square test shows statistic significant at the 0.05 level.

N: Northern Region; M: Middle Swedish Region; SE: South-eastern Region; W: Western region; S: Southern Region.

Table 5. Hospitalisation time according to the type of surgical method for the six regions.

| Regions | N | | | M | | | SG | | | SE | | | W | | | S | | | Total, for each method of surgery | | |
|------------|-----|------|-----|-----|------|-----|-----|------|-----|-----|------|-----|-----|------|-----|------|------|-----|-----------------------------------|------|-----|
| | Nr | Mean | SD | Nr | Mean | SD | Nr | Mean | SD | Nr | Mean | SD | Nr | Mean | SD | Nr. | Mean | SD | Nr | Mean | SD |
| EDC10, SSO | 154 | 2.3* | 0.8 | 217 | 2.5 | 1.2 | 347 | 1.7* | 0.7 | 267 | 3.4* | 0.9 | 350 | 2.4 | 1.0 | 562 | 1.8* | 0.8 | 1897 | 2.8 | 1.0 |
| EDC15, VRO | 30 | 3.0* | 0.4 | 10 | 2.4 | 1.0 | 73 | 1.9* | 0.5 | 0 | 0 | 0.0 | 5 | 1.1* | 0.5 | 80 | 1.2* | 0.5 | 192 | 1.7 | 0.6 |
| EDC30, GP | 10 | 2.1 | 1.0 | 27 | 2.8* | 1.3 | 35 | 1.6* | 0.6 | 24 | 3.1* | 1.0 | 36 | 2.3* | 1.2 | 102 | 1.9* | 1.0 | 234 | 2.8 | 1.2 |
| EEC00, MSO | 53 | 2.5* | 0.7 | 19 | 1.3* | 0.5 | 20 | 1.7* | 0.8 | 14 | 3.6* | 1.3 | 89 | 2.3* | 1.0 | 58 | 1.4* | 0.6 | 253 | 2.6 | 1.0 |
| EEC05, LF1 | 170 | 2.2* | 0.9 | 253 | 2.4 | 1.2 | 384 | 1.8* | 0.6 | 194 | 3.5* | 1.0 | 335 | 2.4 | 1.0 | 641 | 1.7* | 0.8 | 1977 | 2.8 | 1.1 |
| Total | 417 | 2.0 | 0.8 | 526 | 1.9 | 0.1 | 859 | 1.4 | 0.6 | 499 | 3.4 | 0.8 | 815 | 2.1 | 0.9 | 1443 | 1.6 | 0.7 | 4553 | 2.5 | 1.0 |

SSO: sagittal split osteotomy (uni- or bilateral); VRO: vertical ramus osteotomy; GP: genioplasty; MSO: maxillary segmental osteotomy; LF1 :Le Fort I osteotomy.

*Post-hoc test (Games Howell), comparisons between the regions (statistic is significant at the 0.05 level).

N: Northern Region; M: Middle Swedish Region; SE: South-eastern Region; W: Western region; S: Southern Region; LOS: length of stay (days); Nr: number of patients; SD: standard deviation.

Table 6. Hospitalisation time for patients with single jaw surgery or bimaxillary surgery, repeated surgery-patients included.

| Regions | Single jaw surgery | | | | | | Bimaxillary surgery | |
|-------------|--------------------|--------------------|------------|--------------------|------------|--------------------|------------------------------------------------------|--------------------|
| | EDC10, SSO | | EDC15, VRO | | EEC05, LF1 | | EDC10 + EEC05, SSO + LF1 or EDC15 + EEC05, VRO + LF1 | |
| | Mean/Days | Standard Deviation | Mean/Days | Standard Deviation | Mean/Days | Standard Deviation | Mean/Days | Standard Deviation |
| N | 2.1 | 1.0 | 3.1 | 3.1 | 1.8 | 1.2 | 3.0 | 2.2 |
| M | 2.0 | 1.4 | 2.0 | 2.0 | 1.9 | 1.1 | 2.9 | 1.4 |
| SG | 1.4 | 0.6 | 1.7 | 1.7 | 1.4 | 0.6 | 2.0 | 0.5 |
| SE | 3.2 | 1.1 | . | . | 3.1 | 1.3 | 3.8 | 0.9 |
| W | 2.2 | 0.9 | 2.0 | 2.0 | 2.1 | 0.9 | 2.7 | 1.3 |
| S | 1.7 | 0.8 | 1.0 | 1.0 | 1.4 | 0.7 | 1.9 | 0.8 |
| All regions | 2.0 | 1.1 | 1.5 | 1.5 | 1.8 | 1.0 | 2.5 | 1.3 |

SSO: sagittal split osteotomy (uni- or bilateral); VRO: vertical Ramus osteotomy; LF1: Le Fort I Osteotomy.

N: Northern Region; M: Middle Swedish Region; SG: Stockholm Region; SE: South-eastern Region; W: Western Region; S: Southern Region.

Post-hoc test Games Howell $p < 0.001$ for Single jaw surgery/Bimaxillary surgery.

possible for an underestimation in the NBHR, if care givers fail to register procedures. Even though modern health care systems try to handle data with strict routines and digitalisation, a registry can never give better information than what is the lowest ambition of the the data collectors working for the registry.

In the present study, patients with bimaxillary surgery stayed longer in hospital compared to patients who had single jaw surgery, which was expected. Patients with repeated surgery were not excluded from this analysis as repeated surgery is not expected to change the length of hospital stay. We also found that there was a statistically significant regional difference between the length of stay and the extent of surgery (single jaw surgery or bimaxillary surgery). It is expected that the average number of days in ward care will be reduced during the coming 10 years due to a shortage of 'beds' for in ward care in Sweden.

The present study has several limitations. The reporting of cases to The National Board of Health and Welfare's registry is based on information from patients' medical documents. Errors due to a lack of registration or incorrect registration might occur in the data studied. Consequently, this would possibly result in an underestimation of the number of orthognathic procedures.

It was decided to include patients for a period of 5 years as the frequency of surgery varies between different years. For similar reason regional comparisons were made instead of comparing hospitals. It could be considered an inclusion bias that data from two maxillofacial clinics are missing in the registry for the years we studied.

The necessity of orthognathic surgery is difficult to establish as the indication for surgery is based on both surgeons and orthodontists knowledge and experience. This can result in a variety of regimes. Another important issue to consider is if the coding of cases might differ between surgeons and within hospitals. One suggestion is to validate these results in comparison to other national databases.

The chosen method for the adjustment of the population due to where the patients had their orthognathic surgery, if it was not performed in their own region, is not ideal. However, it was the only method possible, as we had no information about which region the patients belonged to.

It was decided to exclude those patients having orthognathic surgery more than once during 2010-2014, as this group (94 patients) would make statistical analysis extremely complicated. From the available data the reason for surgery more than once could not be extracted, i.e. repeated surgery could be due to stepwise procedure or reoperation. An exception was made when it came to analysis of hospitalisation time, as this time is not expected to be influenced by the cause of the repeated surgery.

Conclusions

This database study estimated the prevalence and distribution of orthognathic surgeries performed between 2010 and 2014 in Sweden. We found regional differences regarding the patients' age at surgery and the number of performed

orthognathic interventions per 100,000 inhabitants in Sweden. In addition, hospitalisation time varied between the regions. However, no significant difference related to sex was found. The reason for regional differences in orthognathic surgical treatment is likely multifactorial. A lack of distinct diagnostic criteria as indication for surgery might be one reason for these differences. Our findings warrant further investigation.

Ethical approval

The study was approved and updated by the Regional Ethical Board in Linköping, Sweden (2017/242-32). All the data was handled in compliance with the Helsinki Declaration.

Patient consent

No patient consent was required as no patients could be identified in the dataset.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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