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Research Article

Survey on retention procedures and use of thermoplastic retainers among orthodontists in Norway, Sweden, and Denmark

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ABSTRACT

Background: Orthodontic retention is the most important factor after successful orthodontic treatment. The use of thermoplastic retainers has increased in recent years, but information is lacking about the product materials and orthodontists' awareness of the products they use. The aim of this survey was to map the retention protocols among Scandinavian orthodontists, particularly their use of thermoplastic retainers. Furthermore, the aim was to investigate their knowledge of thermoplastic materials and record any possible adverse effects.

Methods: An online questionnaire was prepared, and 667 orthodontists in Norway, Sweden, and Denmark were invited to take the survey. The survey was sent to all members of the national orthodontic associations using Nettskjema in Norway and Microsoft Forms in Sweden and Denmark. Data were collected anonymously and analyzed using chi-square and correlation coefficients.

Results: Of the 667 orthodontists, 432 (64%) responded (59% female). The most common retention protocol (51%) was fixed retainer in both maxilla and mandible and thermoplastic retainer in the maxilla. Two-thirds of the orthodontists were unaware of the thermoplastic material used, and 58% did not acquire knowledge of the materials. Only 1% of the respondents had registered adverse reactions to thermoplastic retainers, and none were aware of the type of material that was used.

Conclusions: Scandinavian orthodontists use similar retention protocols, with the most common being fixed retainer in the mandible and dual retention, fixed, and thermoplastic retainer in the maxilla. Orthodontists' knowledge about thermoplastic materials was insufficient, but adverse effects related to thermoplastic retainer use were rare.

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1. Introduction

Maintenance of orthodontic treatment results is probably the most critical and challenging aspect of orthodontics [1]. Throughout the years, several treatment factors, such as good intercuspation and maintenance of the intercanine distance, have been considered pillars of stability. Research, however, shows that the most important predictor for the long-term stability of orthodontic treatment results is the use of a retainer [2,3].

Several surveys on retention have been conducted in different countries in the past decade. Overall, removable retainers are reported to be the most used appliances in the maxilla, alone or in combination with fixed retainers [4–12]. In the mandible, fixed retainers are the most commonly used appliances, although orthodontists in some countries favor removable retainers [13,14]. The Hawley retainer was the primary option for removable retention for many years, although after its introduction, the thermoplastic retainer, also called thermoformed or vacuum-formed retainer, gradually gained popularity and became the preferred removable retainer for most orthodontists. Thermoplastic retainers are aesthetically superior and seem to be more cost-effective

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[15,16]. In contrast, systematic reviews show insufficient evidence to support the use of thermoplastic retainers over Hawley retainers in terms of effectiveness, survival time, and patient satisfaction [17–19]. In addition, the most recent meta-analysis concludes that in the short term, thermoplastic retainers have more adverse effects on periodontal health than Hawley retainers [20].

Despite being the most popular type of retainer worldwide, very little information concerning thermoplastic retainer characteristics is available. Moreover, orthodontists' knowledge about the product materials and possible adverse effects has not been investigated.

This study aimed to investigate the retention protocols used by orthodontists in Norway, Sweden, and Denmark, with particular emphasis on the use of thermoplastic retainers. Furthermore, the aim was to evaluate orthodontists' knowledge about the product materials and to assess if there were any reports on possible adverse effects.

2. Methods and materials

An online questionnaire was sent to 667 orthodontists in Scandinavia. A questionnaire was sent out to all members of the national orthodontic associations in Norway, Sweden, and Denmark (Appendix A found at 10.1016/j.ejwf.2022.05.002). The questionnaire was initially substantiated using Nettskjema, a web tool facilitating submission of answers from any browser, developed and operated by the University Centre for Information Technology at the University of Oslo to design and conduct online surveys following Norwegian privacy requirements. Sample size calculation was performed to determine the response rate needed. The total population of orthodontists in Norway, Sweden, and Denmark according to the national orthodontic associations was 667. Calculation of the sample size using calculator.net resulted in a need for 317 respondents, given a 95% confidence level and a 4% margin of error. The required response rate was 48%.

An initial pilot of the questionnaire was conducted in Norway in November 2019. Validation was performed by five orthodontists who gave feedback on the content of the questions presented, answering possibilities, the order of the questions, and how the technical solution functioned. The input resulted in minor changes to the questionnaire, addition of one question, and alteration of the order of questions.

In Norway, the questionnaire was distributed in Norwegian. It was translated into English for use in Sweden and Denmark, and here, Microsoft Forms was used to distribute the survey. In addition, validation of the translated questionnaire was conducted in a manner similar to that of the validation process used in Norway.

The research ethics committees in all participating countries approved the study: in Denmark, the study was approved by Regional Committees on Health Research Ethics Midtjylland (number 1-10-72-1-20); in Norway, the study was approved by the Regional Committees for Medical and Health Research Ethics (registration number 2019/581); and in Sweden, the study was approved by the Swedish Ethical Review Authority (number 2020-02371).

The survey included 25 questions covering demographics, retention protocols, knowledge of thermoplastic retainer materials, and adverse effects. There were 18 multiple-choice questions presenting two to six possible outcomes, including seven open questions that required a written answer.

The questionnaire was sent digitally to all members of the orthodontic associations in Norway, Sweden, and Denmark from December 2019 until November 2020. As the initial response was low, three to five reminders were sent to gather more data: five in Norway and three in Sweden and Denmark. Because the questionnaire was anonymous, reminders were sent to all members of the associations' member lists.

Table 1
Overview of participants, thermoplastic material they use, and their knowledge of materials

	Norway	Sweden	Denmark	Total
Invited, n	185	313	169	667
Respondents, n	119	210	103	432
Relative response rate, %	64.3	67.1	60.9	64.8
What thermoplastic material do you mostly use?, n (%)				
Polyethylene type	25 (22.7)	22 (10.5)	23 (22.3)	70 (16.2)
Polypropylene type	4 (3.6)	31 (14.8)	0	35 (8.1)
Polyurethane type	3 (2.7)	6 (2.9)	1 (1)	10 (2.3)
Other	4 (3.6)	11 (5.2)	8 (7.8)	23 (5.3)
Do not know	74 (67.3)	140 (66.7)	71 (68.9)	285 (66.0)
Do you acquire knowledge of different products?, n (%)				
Yes	41 (36.6)	100 (47.6)	36 (35.0)	177 (41.0)
No	71 (63.4)	110 (52.4)	67 (65.0)	248 (57.4)

Two authors (TH and AA) performed statistical analysis using IBM SPSS Statistics, version 27.0.0 (IBM Corp., Armonk, NY) and Stata SE 16 (StataCorp LLC, College Station, TX). Means, SDs, and percentages were used to present the data; chi-square and correlation coefficient tests were used to analyze possible differences and relationships of data. $P \leq 0.05$ was considered statistically significant.

3. Results

Overall, the mean response rate was 64% (426 of 667) for all three Scandinavian countries: 64% in Norway (n = 185), 67% in Sweden (n = 313), and 61% in Denmark (n = 169) (Table 1; Appendix B found at 10.1016/j.ejwf.2022.05.002).

3.1. Demographics

The sex distribution was quite similar in Sweden and Denmark, with more female (62% and 69%, respectively) than male orthodontists. In Norway, the sex distribution was more even, with 45% of female orthodontists, significantly less than in Sweden and Denmark (Fig. 1).

Most orthodontists in Sweden and Denmark work in public practices, with no statistical difference between these two countries. The situation is opposite and significantly different in Norway because most orthodontists work in private practices (Fig. 2).

Most of the responding orthodontists have more than 10 years' work experience as orthodontists (approximately 60%), with no significant difference between the countries.

3.2. Retention protocol

All orthodontists used some form of retention. The most common retention protocol in Norway (66%) and Denmark (79%) was dual retention in the maxilla (fixed and removable retainers) and fixed retainers in the mandible. In Sweden, most used only removable retainers in the maxilla (49%), whereas fixed retention was primarily used in the mandible (Fig. 3). The differences in the retention protocol in the maxilla were significant, as Swedish orthodontists used only removable retention in the maxilla more frequently than orthodontists in Norway and Denmark.

Overall, the most used removable retainer was the thermoplastic retainer (Fig. 4). The Norwegian questionnaire allowed the responders to give two answers, which made the total exceed 100%.

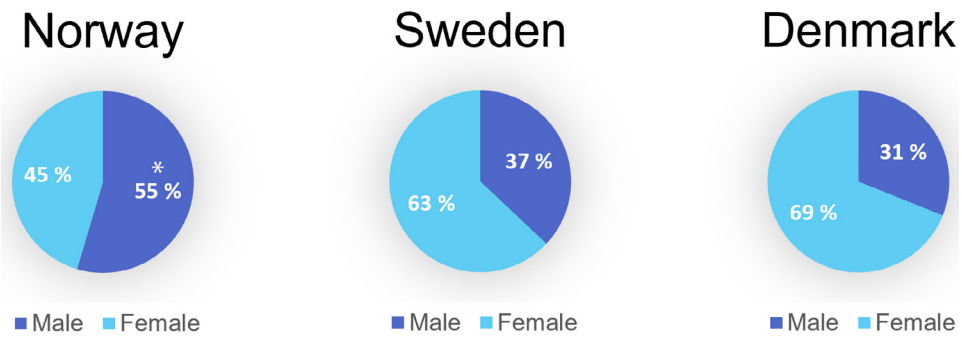

Fig. 1. Overview of sex distribution among respondents in Denmark, Norway, and Sweden. *Significantly more male orthodontists in Norway than in Denmark and Sweden ($P \leq 0.05$).

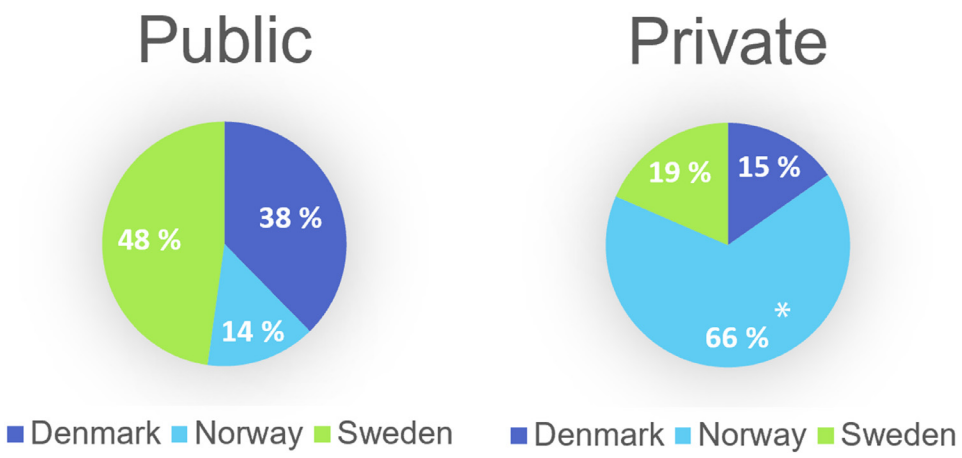

Fig. 2. Main workplace of the respondents. *Significantly more orthodontists in private practices in Norway than in Denmark and Sweden ($P \leq 0.05$).

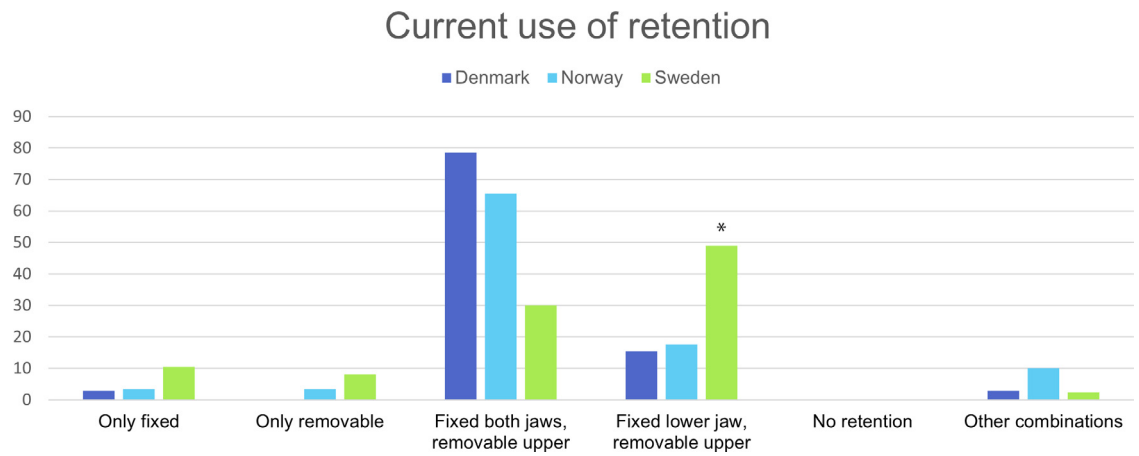

Fig. 3. Retention protocols used in different countries expressed in percentile (%). *Significantly more use of only removable retainer in the maxilla in Sweden than in Denmark and Norway ($P \leq 0.05$).

Nevertheless, there were significant differences between the countries, as orthodontists in Norway and Sweden use thermoplastic retainers significantly more than orthodontists in Denmark.

Availability was the main reason for choosing thermoplastic retainers for all Scandinavian orthodontists (Fig. 5). Quality was the second most important reason for choosing thermoplastic retainers. The results from Norway and Sweden were identical; 23% considered quality an important factor, whereas significantly fewer Danish orthodontists (9%) regarded it as an essential factor. Recommendations and cost seemed equally important for Norwegian orthodontists, whereas Swedish and Danish orthodontists considered recommendations more important than costs. Both countries differed significantly from Norway: <10% of the orthodontists in Sweden and Denmark reported cost as an influencing factor in the choice of thermoplastic retainers, whereas 26% of Norwegian orthodontists regarded cost as the main factor (chi-square 144.9; $P < 0.001$) (Fig. 5).

Furthermore, 37% of orthodontists in Norway and 35% in Denmark reported acquiring knowledge of different thermoplastic retainer products before using them. In Sweden, 48% of orthodon-

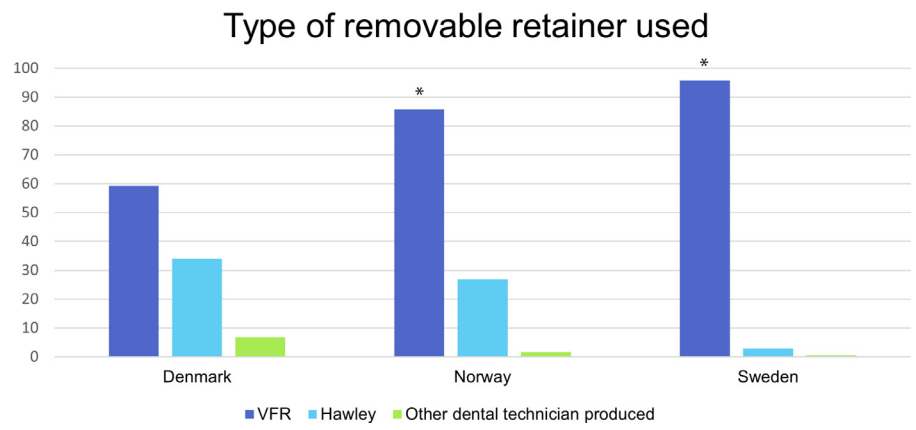

Fig. 4. Type of removable retainer used expressed in percentile (%). *Significantly more use of thermoplastic retainers in Norway and Sweden than in Denmark ($P \leq 0.05$). VFR, vacuum-formed retainer.

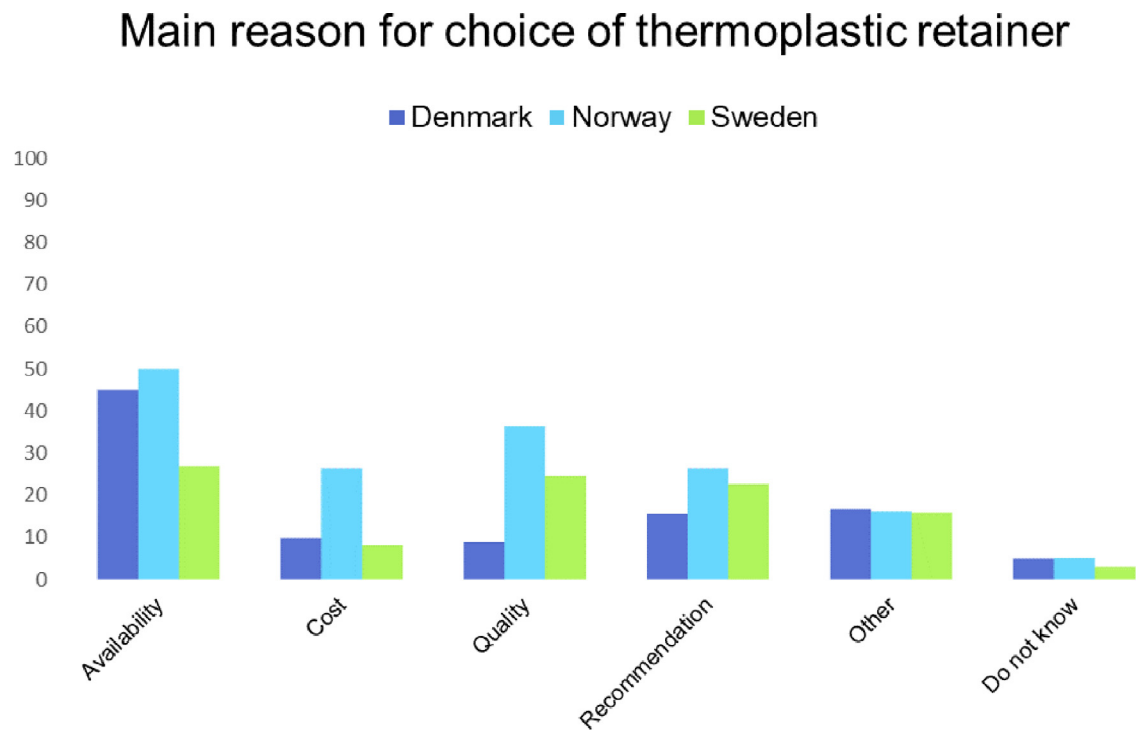

Fig. 5. Overview of the main reason for choosing thermoplastic retainer expressed in percentile (%). *$P \leq 0.05$.

tists searched for information about various products before use. Orthodontists in all three countries showed insufficient knowledge about different materials used for manufacturing thermoplastic retainers. For example, approximately two-thirds of the orthodontists were unaware of the type of material they most commonly used in their thermoplastic retainers (Table 1).

3.3. Side effects

Of 432 respondents, four respondents (1%) had registered an adverse effect related to the use of thermoplastic retainers. One of the responses was clicking in the temporomandibular joint that improved on removal of the thermoplastic retainer. The other three were related to allergic reactions of the gingiva, lips, and skin (one in each category), but none of the responders recognized what kind of material caused the side effect.

There were several significant but very weak correlations (<0.2). For example, recently graduated orthodontists were more interested in and aware of the type of material used for thermoplastic retainers. A significant correlation was also found between the use of Hawley retainers and orthodontists with >20 years' experience, but the correlation was very weak (<0.2).

4. Discussion

The survey aimed to map and compare retention protocols used in the three Scandinavian countries, with a particular emphasis on the use of thermoplastic retainers, and to map potential allergic reactions to thermoplastic materials and orthodontists' knowledge of these materials.

The response rate varied between the countries, ranging from 61% to 67%, which was considered reasonable compared with similar surveys [13,14]. In contrast, survey response rates have de-

clined over the years. Although there is no scientifically proven minimum response rate, 60% is suggested as a level of adequacy [21]. Higher response rates have been demonstrated with article surveys than with electronic surveys, but the former are expensive and time-consuming [22,23]. Furthermore, the costly pursuit of a high response rate may offer no reduction of nonresponse bias [24]. Therefore, the results obtained from this study are considered reliable, and they reflect the current retention protocols in Norway, Sweden, and Denmark.

Scandinavian countries have many similarities in language, social system, education, and quality of life [25]. Despite apparent outward similarities, the countries, however, differ in some demographic parameters and, relevant for this study, in the organization of the orthodontic health-care system. The questionnaire revealed that in Norway, there were more male orthodontists, and the orthodontists primarily worked in private clinics, whereas in Sweden and Denmark, there were more female orthodontists, and the orthodontists worked mainly in municipal dental care centers. This significant difference is probably owing to the organization and funding of the orthodontic dental care systems in the different countries. In Sweden and Denmark, orthodontic treatment is covered and performed mainly in public clinics, whereas the health authorities in Norway only partly reimburse orthodontic treatment, and most orthodontists work in private clinics.

These demographic differences did not seem to affect the choice of retention protocols. All orthodontists used retention after active orthodontic treatment, and the main protocol was dual retention in the maxilla and fixed retainer in the mandible. This survey showed similar results for Norway compared with earlier findings [10]. No comparison with earlier studies was possible for the results from Sweden and Denmark, as, to our knowledge, this was the first retention protocol survey in these countries. In Norway and Denmark, dual retention in the maxilla was most common, whereas in Sweden, only removable maxillary retainers were significantly more frequent.

Thermoplastic retainers were the most used removable retainer in all participating countries, which is in accordance with other national surveys [4,9]. Their increasing popularity can in some instances be explained by their aesthetics, cost-effectiveness, and quick and easy fabrication [16]. In terms of post-treatment stability, patient satisfaction, and survival time, there seems to be no evidence to support the use of thermoplastic retainers over Hawley retainers [19]. Furthermore, patients wearing thermoplastic retainers are shown to be more prone to gingival inflammation [20]. The increasing use of plastic materials in orthodontics may be alarming and adds to the growing concern about plastic pollution worldwide [26]. Despite the advantages that thermoplastic retainers offer to the patient and clinician, the environmental impact of their disposal is unknown.

Overall, very few adverse effects (1%) related to thermoplastic retainer use were registered in this survey. A report from the Manufacturer and User Facility Device Experience database in the United States highlighted the following adverse clinical events during Invisalign treatment: difficulty breathing, swollen lips, and swelling of gums [27]. These side effects were not related to the total number of Invisalign-treated patients; therefore, it is difficult to compare the incidence of adverse reactions with that observed in our study. No other reports concerning thermoplastic retainers have been found for comparison. Nevertheless, the main product materials, such as polyethylene and polyurethane, as well as plastic modifiers can cause adverse effects, although studies conducted so far are inconclusive on whether thermoplastic retainer use could be harmful [28].

None of the orthodontists reporting adverse effects knew what kind of material the patient had been exposed to. A concerning finding was that two-thirds of the orthodontists were not aware of what kind of material they used in their removable retainers [29,30]. In Scandinavia, thermoplastic retainers are usually made “in office” by a dental nurse or dental secretary, and this may partly explain the lack of knowledge about the product materials. Nonetheless, this does not explain the lack of interest in seeking knowledge about the thermoplastic materials used. Given the large number of patients using thermoplastic retainers and the potential long-term side effects of plastic materials, it would be of interest to investigate more closely the substances regarded as potentially harmful. In addition, this survey highlighted the need for enhancement of orthodontists’ knowledge of dental materials.

An interesting and slightly significant finding was that more of the newly graduated orthodontists acquire knowledge of thermoplastic materials compared with the more experienced orthodontists. This might be attributed to the fact that the new generation of orthodontists has become more aware of the possible side effects of plastic materials. Another interesting and significant finding was the impact of cost on the choice of thermoplastic retainers. Of note, more Norwegian orthodontists regarded cost as the main factor when choosing a retainer. It is tempting to speculate that this is associated with the distribution and number of private orthodontists in Norway compared with Sweden and Denmark, where the main bulk of orthodontists work in public offices.

This study collected data from three comparable countries and participating orthodontists from different work locations. The average response rate of 64% gave a low margin of error. Although the response rate was fair compared with similar studies, it would have greater impact if it was even higher. The inputs from an initial pilot questionnaire and validation in each country, which included five orthodontists who provided feedback, made this questionnaire more robust. The involvement of several countries and orthodontists in private and public practices, including universities, also strengthened this survey. Nevertheless, it would be beneficial to conduct similar surveys in different countries and continents to compare and confirm or refute these findings.

5. Conclusions

In general, all Scandinavian orthodontists use similar retention protocols. The most common retention protocol was dual retention in the maxilla and fixed retainer in the mandible. Although thermoplastic retainers were the most popular removable retainers, two-thirds of the orthodontists were unaware of the material used in the fabrication of the retainers. Adverse effects related to the thermoplastic retainer materials were rare.

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Ethical approval

Ethical approval was provided by the Regional Committees for Medical and Health Research Ethics (REC) registration number 2019/581 in Norway, by the Swedish Ethical Review Authority number 2020-02371 in Sweden, and by the Regional Committees on Health Research Ethics Midtjylland number 1-10-72-1-20 in Denmark.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejwf.2022.05.002.

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