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Training in pediatric neurogastroenterology and motility across Europe: a survey of the ESPGHAN National Societies Network 2016-2019

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Abstract

Background Pediatric gastrointestinal motility disorders present significant challenges for diagnosis and management, emphasizing the need for appropriate training in Pediatric Neurogastroenterology and Motility (PNGM). The aim of this survey, part of a comprehensive survey on training in pediatric gastroenterology, hepatology and nutrition, was to evaluate training related to PNGM across European training centers.

Method Standardized questionnaires were collected from training centers through the National Societies Network of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), from June 2016 to December 2019.

Results In total, 100 training centers from 19 countries participated in the survey. Dedicated PNGM clinics were available in 22 centers; pH-monitoring in 60; pH/impedance in 66; standard manometry in 37; and high-resolution manometry in 33. If all motility studies were performed partially or fully by the trainees, the median (range) annual numbers/per trainee were as follows: pH-monitoring 30 (1-500); pH/impedance 17 (1-131); standard manometries 10 (1-150); and high-resolution manometries 8 (1-75). The motility assessment was performed by pediatric gastroenterologists (43 centers); adult gastroenterologists (10 centers); pediatric surgeons (5 centers); and both pediatric gastroenterologists and pediatric surgeons (9 centers). Annual numbers ≤10 for pH-monitoring, pH/impedance, standard manometries and high-resolution manometries were reported by 7 (12%), 15 (23%), 11 (30%) and 14 (42%) centers, respectively.

Conclusions Significant differences exist in PNGM-related infrastructure, staff and procedural volumes at training centers across Europe. ESPGHAN and the National Societies should take initiatives to ensure the acquisition of competence in PNGM-related knowledge and skills, and develop strategies for assessment and accreditation.

An infographic is available for this article at: http://www.annalsgastro.gr/files/journals/1/earlyview/2022/Infographic-AG6486.pdf

Keywords Gastrointestinal motility training, children, training in pediatric gastroenterology, hepatology and nutrition

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Introduction

Pediatric neurogastroenterology and motility (PNGM) disorders are common and have significant impacts on patients, their families and healthcare services. They are related to impaired motility (motor) and sensory function of the gastrointestinal (GI) tract, including dysfunctional interactions between the enteric nervous system, central nervous system and microbiota [1]. PNGM disorders include gastroesophageal reflux disease, esophageal achalasia, gastroparesis, functional dyspepsia, pediatric intestinal pseudo-obstruction, irritable bowel syndrome, functional constipation, slow-transit constipation, fecal incontinence, and Hirschsprung's disease [2]. Their early recognition, proper evaluation and diagnosis can improve patients' clinical outcomes and quality of life, while decreasing healthcare costs [2-4].

Trainees in pediatric gastroenterology, hepatology and nutrition (PGHN) require comprehensive exposure to the diagnosis, management and treatment of GI motility disorders, as well as to their pathophysiology and complications. Although clinical investigation and management constitute important parameters of the PGHN training curriculum, considerable concerns remain regarding the availability of appropriate training. A cross-sectional survey of PGHN trainees in North America found that 75.1% of the fellows believed they had not been adequately trained in PNGM, with the majority reporting not feeling comfortable performing GI motility techniques (57-95.1%) or interpreting GI motility studies (51.3-95%) [5]. Rao and Parkman indicated that only 25% of adult gastroenterology fellowship programs in North America provide trainees with some training in motility and 12% with comprehensive training in this field [1]. To date there are no studies regarding the adequacy of such PNGM training in Europe.

In 2013, the North American Society of Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN) and, in 2018, the American Neurogastroenterology and Motility Society (ANMS), in collaboration with the European Society of Neurogastroenterology and Motility (ESNM), created a framework for substantial training in GI motility [6,7]. This survey, part of a comprehensive study of training in pediatric gastroenterology, hepatology and nutrition across Europe, aims to specifically evaluate the availability of training in PNGM in terms of the provision of appropriate resources for training, as well as GI motility procedural volumes, across European training centers.

Materials and methods

Questions collecting data on PNGM infrastructure, staff, and number of procedures (pH monitoring, pH/impedance, total standard and total high-resolution manometers) at PGHN training centers across Europe were included in a standardized questionnaire published before [8] created by the members (AP, AB and CRC) of the Executive Committee of the National Societies Group 2015-2017 of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN). These were then sent to the Presidents/

Representatives of the ESPGHAN National Societies, who forwarded the questionnaires to PGHN training centers throughout their countries and collected their responses. In countries where there was no response to the initial request (Italy, Portugal and Switzerland), either centers provided completed questionnaires directly to the study coordinators (Portugal), or the questionnaires were redistributed via volunteers from those countries (AG for Italy and RF for Switzerland). The ESPGHAN-funded project, approved by the ESPGHAN Council in 2016, was carried out from June 1, 2016 to December 31, 2019. The data and manuscript were then sent for review by, and constructive comments from, 2 invited experts in PNGM (MB and NT).

Statistical analysis

Appropriate statistical analysis was performed with the use of IBM SPSS software. Descriptive statistics was performed to characterize study groups. Continuous data were tested for normality using the Kolmogorov-Smirnoff test and graphical methods (histogram, Q–Q plot). The Student's *t*-test was used to assess differences between groups for normally distributed variables, and the Mann-Whitney *U* test for skewed variables. For categorical data, the χ^2 test was used, or Fisher's exact test where data were not suitable for χ^2 testing. ANOVA or the Kruskal-Wallis test were used to test for differences in continuous variables among more than 2 groups, according to the variables' distribution. Correlations among continuous variables were analyzed using Spearman's or Pearson's test, according to the variables' distribution. Factors found to be statistically significant in univariate analyses were included in the multivariate analyses in order to identify independent associations, if possible. All statistical analyses were performed using the statistical package PSAW Statistics 21 (SPSS, Inc., Chicago, IL, USA). Statistical significance was set at $P<0.05$.

Results

Summary of responding centers

Of the 188 PGHN training centers originally contacted, 100 responders from 17 European countries, Turkey and Israel participated in our survey, the list of which has already been published previously [8]: 70 were national referral centers—43 in pediatric gastroenterology, hepatology and nutrition (PGHN; Group 1), 14 in pediatric hepatology +/- liver transplantation (PH +/- LT; Group 2), and 13 in pediatric gastroenterology (PG; Group 3)—while 30 were regional referral centers. Only one center (London Great Ormond Street hospital) indicated that it was a national referral center in PNGM. Thirty training centers were in the capitals of the 19 countries, of which 29 were national referral centers—20 in PGHN (Group 1), 3 in PH +/- LT (Group 2), and 6 in PG (Group 3), while 1 was a regional referral center. Fifty-five of the responses came from 12 countries (Austria, Bulgaria, Czech Republic, Croatia, Hungary, Israel, Germany, Lithuania, Portugal, Switzerland, Turkey, United Kingdom), where PGHN is officially recognized, whilst 45 were from 7 countries (Belgium, France, Greece, Italy, The Netherlands, Slovenia, and Spain) where it is not. In Austria and Bulgaria, certification of training in PGHN is granted after an overall assessment of a trainee's portfolio, while in the other countries where PGHN is officially recognized, certification of training in PGHN involves a formal examination at the end of the training. It should be noted however, that an official certification of competence in PNGM at the end of training, similar to the certification for endoscopies that exists in the United Kingdom (https://www.jets.thejag.org.uk/), is not mandatory in any European country.

Resources

Dedicated PNGM clinics

Only 25 centers answered the relevant question and 22 of them had dedicated PNGM clinics: 20 were national referral centers and 2 were regional centers (10 centers in European capitals and 12 in other cities). Among the groups of the national referral centers, dedicated PNGM clinics were available in 14 centers in Group 1, 2 in Group 2 and 4 in Group 3.

Staffing

Specialist nurses were available in all centers with dedicated PGNM clinics. Training centers with a dedicated PNGM clinic were more likely to have full-time or part-time nutritionists compared with the other centers: they were available in 8/10 (80%) and 5/10 (50%), respectively, of the training centers with a dedicated PNGM clinic but in only 19/31 (61%) and 11/28 (39%), of the other centers ($P=0.278$ and $P=0.556$, respectively). Dietitians attached to the training centers were available in a similar number of centers with a dedicated PNGM clinic and in other centers: 15/21 (71%) and 57/74 (77%), respectively ($P=0.597$). Training curricula and clinical leads to supervise the training were available in 18/21 (86%) and 17/21 (81%) of centers with a dedicated PNGM clinic.

Pediatric GI motility investigations

pH-monitoring was available in 60/77 (78%) of training centers that participated in the survey and responded to the relevant question: pH/impedance in 66/85 (78%); standard manometries in 37/80 (46%) and high-resolution manometries in 33/81 (41%). The availability of GI motility testing (Table 1), as well as the procedural volume of the training centers (Table 2), differed amongst training centers, with considerable numbers (7, 15, 11 and 14) of training centers reporting the performance of very low (<10) numbers of pH-monitoring, pH/impedance, standard and high-resolution manometries (overall without specifying the type of standard or high

manometries), respectively (Table 2). The annual procedural volumes of motility studies performed by the different types of training centers are shown in Supplementary Tables 1 and 2.

We were interested to see whether the larger volume of GI motility testing was associated with a larger outpatient volume in a training center. This, however, was not the case, as a considerable number of the centers with the largest outpatient volumes (>5000 per year) performed relatively low numbers (11-50) of GI motility procedures per year: 19% of centers with the above outpatient volume performed 11-50 pH-monitoring studies per year, 19%, performed 11-50 pH/impedance per year, 38% similar numbers of standard manometries per year, while 50% of centers with the largest outpatient volumes (>5000 per year) performed only 11-50 high-resolution manometries per year (Supplementary Table 3). Similar annual numbers (11-50) of high-resolution manometries were also reported by 19% of centers with significantly lower outpatient volumes (501-1500). The numbers were not better if the PH +/- LT centers were omitted from the analysis, considering that these centers do not usually deal with training in GI motility, as 11-50 annual numbers of pH-monitoring, ph/impedance, standard and high-resolution manometries were reported by 30%, 23%, 36% and 58%, respectively, of the training centers with the largest (>5000 per year) outpatient volumes (Supplementary Table 4).

The median (interquartile range [IQR]; range) annual numbers of pH-monitoring, pH/impedance, standard and high-resolution manometry in the whole cohort of training centers that reported availability of the above GI testing were: 50 (25-135; 5-570), 40 (12-100; 5-500), 28 (10-50; 1-465), and 20 (5-35; 1-300), respectively. Dividing the total number of GI motility studies performed at the training center performing the above investigations by the number of trainees in post, the median (IQR; range) annual numbers per trainee were as follows: pH-monitoring 30 (15-71; 1-500); pH/impedance 17 (10-50; 1-131); standard manometry 10 (5-44; 1-150) and high-resolution manometry 8 (3-20; 1-75). The numbers of GI motility studies per trainee in post in different training centers are shown in Supplementary Table 5.

In addition, we were interested to learn who performs the GI motility assessment at the training centers in PGHN across Europe. The GI motility assessment was performed by a pediatric gastroenterologist in 43 centers, an adult gastroenterologist in 10 centers, a pediatric surgeon in 5 centers, and a pediatric gastroenterologist or surgeon in 9 centers.

The training centers with the largest procedural volumes of pH/impedance studies and high-resolution manometries amongst those centers in each country participating in the survey, are shown in Figs. 1 and 2. The Sapienza University of Rome reported the greatest annual numbers of pH/impedance studies amongst the centers participating in the survey, whilst Great Ormond Street hospital in London reported the greatest annual numbers of high-resolution manometries. The numbers of GI motility studies performed by all training centers per 100,000 pediatric inhabitants aged 0-19 years amongst countries which had full representation of the training centers is shown

Table 1 Availability of PNGM investigations at training centers in PGHN across Europe

Tests	National PGHN (n=43)	National PG (n=13)	National PH (n=14)	P-value	Regional (n=30)	European capitals (n=30)	Other cities (n=70)	P-value
pH-monitoring	27/34 (79%)	7/8 (88%)	8/13 (62%)	0.147	18/20 (90%)	18/21 (86%)	42/54 (78%)	0.323
pH/impedance	31/37 (84%)	11/12 (92%)	7/12 (58%)	0.613	17/24 (71%)	22/27 (81%)	44/58 (76%)	0.614
Standard manometry	15/35 (43%)	6/10 (60%)	4/11 (36%)	0.842	12/24 (50%)	10/24 (42%)	27/56 (48%)	0.865
High-resolution manometry	15/36 (42%)	6/11 (55%)	4/12 (33%)	0.662	8/22 (36%)	11/24 (46%)	22/57 (39%)	0.822

PNGM, pediatric neurogastroenterology and motility; PGHN, pediatric gastroenterology, hepatology and nutrition; PG, pediatric gastroenterology; PH, pediatric hepatology; The numerators show the numbers of centers performing the tests, while the denominators, the numbers of centers which answered the relevant question

Table 2 Annual procedural volume of gastrointestinal motility tests performed in the training centers in PGHN across Europe

No of tests	No (%) of centers pH-monitoring (n=60)	No (%) of centers pH-impedance (n=66)	No (%) of centers Standard manometries (n=37)	No (%) of centers High-resolution manometries (n=33)
≤10	7/60 (12%)	15/66 (23%)	11/37 (30%)	14/33 (42%)
11-50	25/60 (42%)	24/66 (36%)	18/37 (49%)	16/33 (48%)
51-100	11/60 (18%)	14/66 (21%)	5/37 (14%)	2/33 (6%)
>100	17/60 (28%)	13/66 (20%)	3/37 (8%)	1/33 (3%)

PGHN, pediatric gastroenterology, hepatology and nutrition ; The numerators show the numbers of centers performing the indicated numbers of tests, while the denominators, the total numbers of centers performing the test

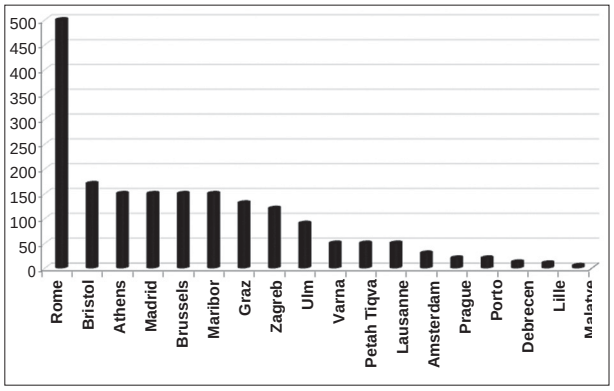

Figure 1 The annual number of pH impedance studies performed by the participating in the survey training centers with the largest procedural volume in each country.
The centers shown in the figure are the following: **Rome** (Department of Pediatrics, Sapienza University, Rome, Italy); **Bristol** (Bristol Children's Hospital , Bristol, UK); **Athens** (Children's hospital Agia Sofia, Athens, Greece); **Madrid** (Niño Jesús University Hospital, Madrid, Spain); **Brussels** (Saint-Luc University Hospital, Brussels, Belgium); **Maribor** (University Medical center, Maribor, Slovenia); **Graz** (Department of Pediatrics, Medical University of Graz, Graz, Austria); **Zagreb** (Children's Hospital Zagreb, Zagreb, Croatia); **Ulm** (University Medical Centre, Ulm, Germany), **Varna** (Saint Marina University hospital, Varna, Bulgaria); **Petah Tiqva** (Schneider Children's Medical Center of Israel, Petah Tiqva, Israel); **Lausanne** (Lausanne University Hospital, Lausanne, Switzerland); **Amsterdam** (Department of Pediatric Gastroenterology and Nutrition, Emma Children's Hospital, Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands); **Prague** (Department of Pediatrics, University Hospital Motol, Prague, Czech Republic); **Porto** (Centro Hospitalar de São João, Porto, Portugal); **Debrecen** (University Children's Hospital, Debrecen, Hungary); **Lille** (Lille University Hospital, Lille, France); **Malatya** (Inönü University Faculty of Medicine, Malatya, Turkey)

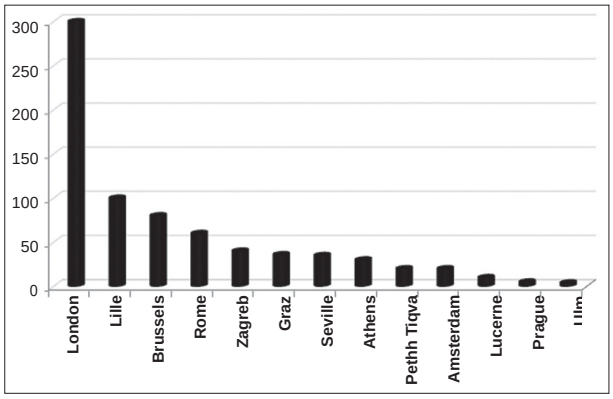

Figure 2 The annual number of high-resolution manometry studies performed by the participating in the survey training centers with the largest procedural volume in each country.
The centers shown in the figure are the following: **London** (Great Ormond Street hospital, London, UK); **Lille** (Lille University Hospital, Lille, France); **Brussels** (Queen Fabiola University Children's Hospital, Libre University, Brussels, Belgium); **Rome** (Bambino Gesù Children's Hospital, Rome, Italy), **Zagreb** (University Hospital Center Zagreb, Zagreb, Croatia); **Graz** (Department of Pediatrics, Medical University of Graz, Graz, Austria); **Seville** (Hospital Infantil Virgen Del Rocio, Seville, Spain); **Athens** (Children's hospital Agia Sofia, Athens, Greece); **Petah Tiqva** (Schneider Children's Medical Center of Israel, Petah Tiqva, Israel); **Amsterdam** (Department of Pediatric Gastroenterology and Nutrition, Emma Children's Hospital, Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands); **Lucerne** (Children's Hospital of Lucerne, Lucerne, Switzerland); **Prague** (Department of Pediatrics, University Hospital Motol, Prague, Czech Republic); **Ulm** (University Medical Centre Ulm, Ulm, Germany)

in Figs. 3 and 4. The population aged 0-19 was taken from the international database of the United States Census Bureau [9].

Discussion

This European-wide study represents the first comprehensive survey of the availability and provision of training in PNGM across European PGHN centers. As part of a larger collaborative study of the ESPGHAN National Societies network, it found considerable diversity in PNGM clinics, procedural volumes and training opportunities across PGHN training centers with, overall, significant limitations in the availability of robust training in PNGM. This study was completed before the onset of the COVID-19 pandemic, which, since early 2020, has considerably affected the availability of GI motility testing, and thus training, worldwide [10]. It is likely, therefore, that this study over-represents the training currently available for PNGM in the European region.

The survey found that only 22 European training centers in PGHN reported the availability of dedicated PNGM clinics and these centers were more likely to have a nutritionist attached to the center. However, a not insignificant percentage of the above centers did not have a training curriculum (14%) or a clinical supervisor (19%) to oversee the training. Certainly, the establishment of dedicated motility clinics, staffed with a multidisciplinary team incorporating psychologists and/or psychiatrists as well as social workers, is desirable, given the inherent overlap of GI motility and functional disorders with psychosocial triggers and impacts [11,12]. Regarding motility testing, pH/impedance was unavailable in 22%, and high-resolution manometry in 59% of centers across Europe. In almost 10 centers, pediatric motility assessments were still being carried out by adult gastroenterologists. It should be noted that limited numbers of motility tests were seen even in centers with large outpatient volumes. The reasons for this discrepancy are not clear, although it is possible that larger expert units have stricter criteria for the performance of GI motility testing. Recently, specialist PGHN organizations have produced a number of guidelines for the performance of motility testing [13-15]. It should be noted, however, that a "competency threshold" for the number of PNGM procedures during PGHN training has not been established. For endoscopy competency, the Joint Advisory Group on Gastrointestinal Endoscopy (JAG) in the United Kingdom awards accreditation for high quality gastrointestinal endoscopy services, while the JAG Endoscopy Training System (https://www.jets.thejag.org.

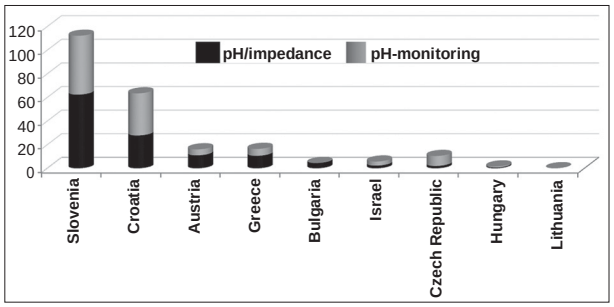

Figure 3 Annual number of pH/impedance and pH-monitoring studies per 100,000 inhabitants 0-19 years of age [9] in the countries with full representation of the training centers

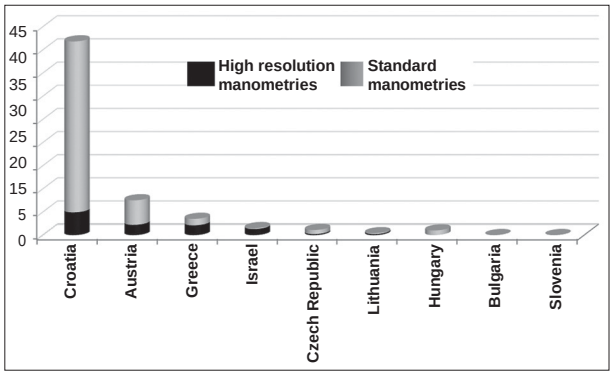

Figure 4 Annual number of high-resolution manometries and standard manometries per 100,000 inhabitants 0-19 years of age [9] in the countries with full representation of training centers

uk/) is a booking portal for endoscopy training courses that provides an electronic portfolio where evidence of endoscopy training can be recorded to apply for JAG certification for trainees. A similar approach could be applied to PNGM services, training procedures and certification in PNGM.

European guidelines for PNGM investigations are currently being prepared. This shortfall does not appear to be unique to Europe. Globally, although GI motility disorders are amongst the most frequently encountered disorders of the GI tract, the number of centers offering specialist NGM training remains very limited. According to the NASPGHAN Motility Center Directory, only 38 motility centers and 54 neurogastroenterologists were available throughout North America in 2015 [16]. The lack of exposure and dedicated training in GI motility during fellowship training provide consistent barriers to pursuing motility-focused careers, with trainees reporting limited comfort in performing and/or interpreting GI motility studies [5]. Similar results were found among adult gastroenterology training programs, given that only 25% of fellowship programs were able to offer some training in motility, while only 12% could offer comprehensive motility training [1]. Graham *et al* [5] conducted a cross-sectional survey among trainees listed as pediatric gastroenterology fellows in North American training programs in 2018, via direct e-mail and the pediatric gastroenterology listserv. Eighty-one pediatric gastroenterology fellows responded to the anonymous survey. A total of 53.1% of the fellows reported interest in PNGM; however, more than 75% believed they had not been adequately trained in PNGM during their fellowship [5]. The percentage of fellows reporting not being comfortable performing various GI motility procedures ranged from 57-95.1% depending on the procedure, or interpreting various GI motility studies ranged from 51.3-95% depending on the study [5].

Our survey showed that the accreditation of competence in PGHN, including in the diagnosis and management of PNGM disorders, is lacking, specifically in European countries in which PGHN is not yet officially recognized as a subspecialty. NASPGHAN has published guidelines for training in PGHN, suggesting a transition to an outcomes-based system (core competencies) [6] focusing on milestones and entrustable professional activities (EPAs) [17]. The NASPGHAN EPA Task force developed 5 EPAs focused on PGHN [18,19], along with an additional one for PNGM disorders, while the American Neurogastroenterology and Motility Society (ANMS) endorsed guidelines regarding training in adult PNGM, based on a 3-tiered approach [7]. Both NASPGHAN and ANMS have established training frameworks on motility disorders, offering understandable and usable knowledge to pediatric and adult motility consultants. More recently, NASPGHAN and ANMS published PNGM training guidelines to serve as a resource to break existing barriers to pursuing a career in NGM and provide a framework towards uniform training expectations in 3 hierarchical tiers corresponding to EPA levels [20].

Clearly, training programs in PNGM in Europe need to be improved. The limited number, and thus availability, of motility centers and neurogastroenterologists is likely to impose significant limitations on the improvement of motility training. In the short term, prior to the development of additional capability, this suggests that collaboration with other regional or national pediatric and/or adult motility centers will be necessary to facilitate comprehensive training in the recognition, diagnosis and management of PNGM disorders [5]. Even where such PNGM training is available, attention needs to be paid to ensure there is focused motility training during PGHN training programs. For those trainees who wish to pursue a career in PGHN, the integration of an additional year of training in advanced motility in a major PNGM center could facilitate the acquisition of extensive clinical and research experience in the field. Graham *et al*, however, reported that only approximately 11% of trainees expressed an interest in advanced motility training, mainly because of financial or geographic issues [5]. The interest of European pediatric PGHN trainees in pursuing a career in PNGM remains to be determined, although the demand for such expertise is likely to remain, given the large numbers and complexity of pediatric motility disorders.

The role of postgraduate courses and/or focused single topic symposia/schools in PNGM to communicate up-to-date knowledge in PNGM issues is crucial [5]. In recent years

ESPGHAN has included PNGM-related knowledge and skills in the subspecialty curriculum and logbook [21,22] and, in collaboration with world experts in the field, has incorporated motility courses, symposia and hands-on training in GI motility techniques in the Society's educational activities. Although a hands-on GI motility learning zone was included in the scientific program of one of its annual meetings (2016), this has not been repeated in subsequent meetings.

This study has a number of limitations. One was the cross-sectional study design and another the variability in response rate. Some countries' reporting, including Austria, Bulgaria, Croatia, Greece, Israel, Slovenia and the United Kingdom, included full representation of their PGHN training centers; others, such as the Scandinavian countries, did not have any representation; while Germany and Turkey had limited representation, as only a few centers participated in the survey. With regard to specialist training in PGHN, however, it is known that German trainees need to verify the performance (albeit without numbers) of pH-monitoring, pH/impedance and GI manometries in order to be certified by the State Medical Association as subspecialists in PGHN [23]. Furthermore, to be certified as training centers for PGHN by the German-speaking Society of PGHN, they must provide treatment and follow up for at least 25 pediatric patients with GI motility disorders per year and seek recertification every 2 years; the certified PGHN training centers (n=36) are shown on the Society's website [24]. In addition, this survey focused on only one part of the assessment of children with neurogastroenterological disorders, while a wider multidisciplinary team, including psychologists/psychiatrists, nutritionists/dietitians, histopathologists and a pediatric/surgical team, is required for their proper management; the availability of such personnel was not studied**.** Notwithstanding the above limitations, this first collaborative work of the ESPGHAN National Societies Network provides the largest dataset on the infrastructure, staff, procedural volumes and training programs in PNGM across Europe.

In conclusion, our large and robust survey across 100 centers in the European region identified heterogeneity, with overall limitations in PNGM training, highlighting the need for harmonization of service infrastructure and training to provide appropriate and timely exposure to GI motility disorders and PNGM testing. In the first instance, National Societies need to take initiatives to ensure competency in the clinical aspects and testing related to GI motility disorders, including access to training rotations in centers (pediatric and/or adult) with high procedural volumes, participation in educational initiatives in PNGM, as well as developing mechanisms for formal assessment of competence and accreditation. ESPGHAN may facilitate such training establishing fellowships in PNGM, such as those now offered annually through ESPGHAN for endoscopy. Implementing strategies to enhance and support the acquisition by the trainees of focused experience on PNGM will increase their interest in following a GI motility-related career path and better prepare them to manage the large and challenging group of GI motility disorders, currently a significant unmet need.

Summary Box

What is already known:

- Gastrointestinal (GI) motility disorders are very common and have a significant impact on patients' and families' quality of life, and healthcare systems
- Training in pediatric neurogastroenterology and motility (PNGM) and the acquisition of technical skills to assess and treat GI motility disorders are integral components of the pediatric gastroenterology, hepatology, and nutrition (PGHN) training curriculum

What the new finding is:

- A wide variation exists in PNGM infrastructure, staffing and number of procedures across European PGHN training centers, leading to limitations in PNGM training opportunities

References

1. Rao SS, Parkman HP. Advanced training in neurogastroenterology and gastrointestinal motility. *Gastroenterology* 2015;**148**:881-885.
2. Thapar N, Benninga MA, Crowell MD, et al. Paediatric functional abdominal pain disorders. *Nat Rev Dis Primers* 2020;**6**:89.
3. Pesce M, Borrelli O, Saliakellis E, Thapar N. Gastrointestinal neuropathies: new insights and emerging therapies. *Gastroenterol Clin North Am* 2018;**47**:877-894.
4. Ambartsumyan L, Rodriguez L. Gastrointestinal motility disorders in children. *Gastroenterol Hepatol (N Y)* 2014;**10**:16-26.
5. Graham K, Belkind-Gerson J, Darbari A, Boyle JT. Barriers in neurogastroenterology and motility training experience for pediatric gastroenterology fellows. *J Pediatr Gastroenterol Nutr* 2019;**68**:806-810.
6. Leichtner AM, Gillis LA, Gupta S, et al; North American Society for Pediatric Gastroenterology. NASPGHAN guidelines for training in pediatric gastroenterology. *J Pediatr Gastroenterol Nutr* 2013;56(Suppl 1):S1-S8.
7. Gyawali CP, Savarino E, Lazarescu A, et al. Curriculum for neurogastroenterology and motility training: A report from the joint ANMS-ESNM task force. *Neurogastroenterol Motil* 2018;**30**:e13341.
8. Papadopoulou A, Ribes-Koninckx C, Noni M, et al. Training in pediatric hepatology across Europe: a survey of the ESPGHAN National Societies Network 2016-2019. *Ann Gastroenterol* 2022 (in press)
9. International Database: World population estimates and projections. Available from: https://www.census. gov/data-tools/demo/idb/#/map?COUNTRY _YR_ ANIM=2021&menu=mapViz&COUNTRY_YEAR= [Accessed 6 March 2022].
10. Tack J, Schol J, Geeraerts A, et al. A survey on the impact of the COVID-19 pandemic on motility and functional investigations in Europe and considerations for recommencing activities in the early recovery phase. *Neurogastroenterol Motil* 2020;**32**:e13926.
11. Rutten JM, Korterink JJ, Venmans LM, Benninga MA, Tabbers MM. Nonpharmacologic treatment of functional abdominal pain

disorders: a systematic review. *Pediatrics* 2015;**135**:522-535.
12. Lackner JM, Jaccard J, Keefer L, et al. Improvement in gastrointestinal symptoms after cognitive behavior therapy for refractory irritable bowel syndrome. *Gastroenterology* 2018;**155**:47-57.
13. Rosen R, Garza JM, Tipnis N, Nurko S. An ANMS-NASPGHAN consensus document on esophageal and antroduodenal manometry in children. *Neurogastroenterol Motil* 2018;**30**:10.1111/nmo.13239.
14. Rodriguez L, Sood M, Di Lorenzo C, Saps M. An ANMS-NASPGHAN consensus document on anorectal and colonic manometry in children. *Neurogastroenterol Motil* 2017;**29**.
15. Mutalib M, Rawat D, Lindley K, et al. BSPGHAN Motility Working Group position statement: paediatric multichannel intraluminal pH impedance monitoring-indications, methods and interpretation. *Frontline Gastroenterol* 2017;**8**:156-162.
16. NASPGHAN - Committees and Special Interest Groups. Available from: https://naspghan.org/about/committees/[Accessed 6 March 2022].
17. Iobst WF, Caverzagie KJ. Milestones and competency-based medical education. *Gastroenterology* 2013;**145**:921-924.
18. Sauer CG, Robson J, Turmelle YP, et al. North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition position paper on entrustable professional activities: Development of pediatric gastroenterology, hepatology, and nutrition entrustable professional activities. *J Pediatr Gastroenterol Nutr* 2020;**71**:136-143.
19. Robson J, Lusman SS, Lee CK, et al. Pediatric Gastroenterology, Hepatology, and Nutrition Entrustable Professional Activities: Development of an assessment tool and curricular resources. *J Pediatr Gastroenterol Nutr* 2020;**71**:e40-e45.
20. Khlevner J, Rosen R, Ambartsumyan L, et al. Development of entrustable professional activities and standards in training in pediatric neurogastroenterology and motility: North American Society for Pediatric Gastroenterology, Hepatology and Nutrition and American Neurogastroenterology and Motility Society position paper. *J Pediatr Gastroenterol Nutr* 2021;**72**:168-180.
21. D'Antiga L, Nicastro E, Papadopoulou A, et al. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition syllabus for subspecialty training: moving towards a European standard. *J Pediatr Gastroenterol Nutr* 2014;**59**:417-422.
22. ESPGHAN Training Syllabus 2019 | ESPGHAN. Available from: https://www.espghan.org/knowledge-center/education/ESPGHAN_Training_Syllabus_2019 [Accessed 6 March 2022].
23. German Medical Association (Working group of German medical associations) (Model). Further Education Regulations 2018 in the version of June 26, 2021. Available from: https://www.bundesaerztekammer.de/fileadmin/user_upload/downloads/pdf-Ordner/Weiterbildung/20210630_MWBO_2018.pdf [Accessed 6 March 2022].
24. The German Society for Pediatric Gastroenterology and Nutrition (GPGE) website. Available from: https://www.gpge.eu/[Accessed 6 March 2022].

Supplementary material

Supplementary Table 1 Annual numbers of gastrointestinal motility tests performed at different types of training centers in PGHN across Europe

No of tests	Tests	National (n = 70)	Regional (n = 30)	P-value*	Eur. Capitals (n = 30)	Other cities (n = 70)	P-value*
≤10	pH/monitoring	5/54 (9%)	2/20 (10%)	P = 0.672	1/21 (5%)	6/53 (11%)	0.305
	pH/impedance	12/61 (20%)	3/24 (13%)	P = 0.320	3/27 (11%)	12/58 (21%)	0.154
	Standard manometry	9/56 (16%)	2/23 (9%)	P = 0.233	3/24 (13%)	8/55 (15%)	0.983
	High-resolution manometry	11/59 (19%)	3/22 (14%)	P = 0.773	2/24 (8%)	12/57 (21%)	0.197
11-50	pH/monitoring	19/54 (35%)	6/20 (30%)	P = 0.672	5/21 (23%)	20/53 (38%)	0.305
	pH/impedance	19/61 (31%)	5/24 (21%)	P = 0.320	7/27 (26%)	17/58 (29%)	0.154
	Standard manometry	11/56 (20%)	7/23 (30%)	P = 0.233	6/24 (25%)	12/55 (22%)	0.983
	High-resolution manometry	12/59 (20%)	4/22 (18%)	P = 0.773	7/24 (29%)	9/57 (16%)	0.197
51-100	pH/monitoring	6/54 (11%)	5/20 (25%)	P = 0.672	5/21 (23%)	6/53 (22%)	0.305
	pH/impedance	7/61 (11%)	7/24 (29%)	P = 0.320	4/27 (15%)	10/58 (17%)	0.154
	Standard manometry	5/56 (9%)	0/23 (0%)	P = 0.233	1/24 (4%)	4/55 (7%)	0.983
	High-resolution manometry	2/59 (3%)	0/22 (0%)	P = 0.773	1/24 (4%)	1/57 (2%)	0.197
>100	pH/monitoring	13/54 (24%)	4/20 (20%)	P = 0.672	7/21 (33%)	10/53 (19%)	0.305
	pH/impedance	10/61 (16%)	3/24 (13%)	P = 0.320	8/27 (30%)	5/58 (9%)	0.154
	Standard manometry	1/56 (2%)	2/23 (9%)	P = 0.233	1/24 (4%)	2/55 (4%)	0.983
	High-resolution manometry	1/59 (2%)	0/22 (0%)	P = 0.773	1/24 (4%)	0/57 (0%)	0.197

*Chi-square was performed to exam possible differences among variables. Categories of the number of tests (<10, 11-50, 51-100, >100) were analyzed as a single variable for each motility study

PGHN, pediatric gastroenterology, hepatology and nutrition; the numerators show the numbers of centers performing the tests, while the denominators, the numbers of centers which answered the relevant question

Supplementary Table 2 Annual numbers of gastrointestinal motility tests performed at national referral centers in PGHN compared to PG or PH alone, across Europe

No of tests	Tests	National PGHN center (n=43)	National PG center (n=13)	National PH center (n=14)	P-value*
≤10	pH/monitoring	3/34 (9%)	1/8 (13%)	1/12 (8%)	0.757
	pH/impedance	6/37 (16%)	1/12 (8%)	5/12 (17%)	0.062
	Standard manometry	6/35 (17%)	1/10 (10%)	2/11 (18%)	0.452
	High-resolution manometry	6/36 (17%)	2/11 (18%)	3/12 (25%)	0.207
11-50	pH/monitoring	13/34 (38%)	2/8 (25%)	4/12 (33%)	0.757
	pH/impedance	14/37 (38%)	3/12 (25%)	2/12 (17%)	0.062
	Standard manometry	7/35 (20%)	2/10 (20%)	2/11 (18%)	0.452
	High-resolution manometry	8/36 (22%)	4/11 (36%)	0/12 (25%)	0.207
51-100	pH/monitoring	5/34 (15%)	0/8 (0%)	1/12 (8%)	0.757
	pH/impedance	5/37 (14%)	2/12 (17%)	0/12 (0%)	0.062
	Standard manometry	3/35 (9%)	2/10 (20%)	0/11 (0%)	0.452
	High-resolution manometry	1/36 (3%)	0/11 (0%)	1/12 (25%)	0.207
>100	pH/monitoring	6/34 (18%)	4/8 (50%)	3/12 (25%)	0.757
	pH/impedance	4/37 (11%)	5/12 (42%)	1/12 (8%)	0.062
	Standard manometry	0/35 (0%)	1/10 (10%)	0/11 (0%)	0.452
	High-resolution manometry	0/36 (0%)	1/11 (9%)	0/12 (0%)	0.207

*Chi-square was performed to exam possible differences among variables. Categories of the number of tests (<10, 11-50, 51-100, >100) were analyzed as a single variable for each motility study

PGHN, pediatric gastroenterology, hepatology and nutrition; PG, pediatric gastroenterology; PH, pediatric hepatology; the numerators show the numbers of centers performing the tests, while the denominators, the numbers of centers which answered the relevant question

Supplementary Table 3 Annual procedural volume of motility tests performed by training centers according to outpatient volumes

Procedural volume	<500 (n=3)	501-1500 (n=18)	1501-3000 (n=33)	3001-5000 (n=25)	>5000 (n=20)
pH-monitoring					
≤10	0/3 (0%)	3/12 (25%)	3/28 (11%)	1/18 (6%)	0/16 (0%)
11-50	1/3 (33%)	5/12 (42%)	10/28 (36%)	4/18 (22%)	3/16 (19%)
51-100	0/3 (0%)	1/12 (8%)	6/28 (21%)	1/18 (6%)	3/16 (19%)
>100	0/3 (0%)	1/12 (8%)	2/28 (7%)	8/18 (44%)	6/16 (38%)
pH/impedance					
≤10	1/3 (33%)	2/17 (12%)	5/27 (19%)	5/21 (24%)	2/16 (13%)
11-50	0/3 (33%)	4/17 (24%)	11/27 (41%)	6/21 (29%)	3/16 (19%)
51-100	0/3 (0%)	3/17 (18%)	2/27 (7%)	6/21 (29%)	3/16 (19%)
>100	0/3 (0%)	3/17 (18%)	2/27 (7%)	2/21 (10%)	6/16 (38%)
Standard manometry					
≤10	1/3 (33%)	2/12 (17%)	6/25 (24%)	1/22 (5%)	1/16 (6%)
11-50	1/3 (33%)	2/12 (17%)	5/25 (20%)	4/22 (18%)	6/16 (38%)
51-100	0/3 (0%)	0/12 (0%)	1/25 (4%)	2/22 (9%)	2/16 (13%)
>100	0/3 (0%)	0/12 (0%)	1/25 (4%)	0/22 (0%)	2/16 (13%)
High-resolution manometry					
≤10	1/2 (50%)	4/16 (25%)	7/28 (25%	1/20 (5%)	1/14 (7%)
11-50	0/2 (0%)	3/16 (19%)	3/28 (11%)	3/20 (15%)	7/14 (50%)
51-100	0/2 (0%)	0/16 (0%)	1/28 (4%)	1/20 (5%)	0/14 (0%)
>100	0/2 (0%)	0/16 (0%)	0/28 (0%)	0/20 (0%)	1/14 (0%)

The numerators show the numbers of centers performing the tests, while the denominators, the numbers of centers which answered the relevant question

Supplementary Table 4 Annual procedural volume of motility tests performed by training centers excluding hepatology +/- liver transplantation centers, according to outpatient volumes

Procedural volume	<500 (n=3)	501-1500 (n=17)	1501-3000 (n=26)	3001-5000 (n=22)	>5000 (n=17)
pH-monitoring					
≤10	0/3 (0%)	2/11 (18%)	2/22 (9%)	1/15 (7%)	0/10 (0%)
11-50	1/3 (33%)	5/11 (36%)	9/22 (41%)	3/15 (20%)	3/10 (30%)
51-100	0/3 (0%)	1/11 (9%)	5/22 (23%)	1/15 (7%)	1/10 (10%)
>100	0/3 (0%)	1/11 (9%)	2/22 (9%)	6/15 (40%)	5/10 (50%)
pH-impedance					
≤10	1/3 (33%)	1/16 (6%)	4/22 (18%)	4/18 (22%)	0/13 (0%)
11-50	0/3 (0%)	4/16 (25%)	10/22 (46%)	5/18 (28%)	3/13 (23%)
51-100	0/3 (0%)	3/16 (19%)	2/22 (9%)	6/18 (33%)	3/13 (23%)
>100	0/3 (0%)	3/16 (19%)	2/22 (9%)	1/18 (6%)	6/13 (46%)
Standard manometry					
≤10	1/3 (33%)	1/11 (9%)	5/20 (25%)	1/19 (5%)	1/14 (7%)
11-50	1/3 (33%)	2/11 (18%)	5/20 (25%)	4/19 (16%)	5/14 (36%)
51-100	0/3 (0%)	0/11 (0%)	1/20 (5%)	2/19 (11%)	2/14 (14%)
>100	0/3 (0%)	0/11 (0%)	1/20 (5%)	0/19 (0%)	2/14 (14%)
High-resolution manometry					
≤10	1/2 (50%)	4/15 (27%)	5/22 (22%)	0/17 (0%)	1/12 (8%)
11-50	0/2 (0%)	3/15 (20%)	3/22 (14%)	2/17 (12%)	7/12 (58%)
51-100	0/2 (0%)	0/15 (0%)	1/22 (5%)	0/17 (0%)	0/12 (0%)
>100	0/2 (0%)	0/15 (0%)	0/22 (0%)	0/17 (0%)	1/12 (8%)

The numerators show the numbers of centers performing the tests, while the denominators, the numbers of centers which answered the relevant question

Supplementary Table 5 Median (IQR; range) numbers of trainees in training centers and median (IQR; range) of motility tests per trainee

Parameters	National PGHN (n=43)	National PG (n=13)	National PH (n=14)	P-value	National (n=70)	Regional (n=30)	P-value	European capitals (n=30)	Other cities (n=70)	P-value
Trainees	2 (1-3; 1-6)	2 (1-5; 0-10)	2 (1-2; 0-5	0.589	2 (1-3; 0-10)	2 (1-3; 0-10)	0.186	2 (1-4, 1-10)	2 (1-2, 0-7)	0.058
pH-monitoring	28 (13-77; 1-500)	87 (27-150; 18-150)	14 (11-28; 4-50)	0.049	28 (13-70; 1-500)	30 (19-74; 5-123)	0.554	30 (13-73; 4-200)	30 (15-69; 1-500)	0.903
pH/impedance	15 (10-50; 1-125)	45 (26-73; 10-131)	5 (3-13; 2-15)	0.003	15 (10-50; 1-500)	25 (14-53; 5-85)	0.393	25 (12-58; 5-125)	15 (7-50; 1-85)	0.126
Standar dmanometry	10 (5-25; 1-100)	42 (10-75; 10-84)	5 (5-NA; 3-5)	0.167	10 (5-44; 1-100)	14 (6-119; 3-150)	0.479	15 (5-63; 3-100)	10 (5-34; 1-150)	0.767
High-resolution manometry	5 (3-20; 1-40)	19 (9-41; 4-75)	2 (1-16; 1-20)	0.081	6 (3-20; 1-75)	13 (7-26; 5-30)	0.392	20 (8-45; 3-75)	5 (2-13; 1-30)	0.004

PGHN, pediatric gastroenterology, hepatology and nutrition; PG, pediatric gastroenterology; PH, pediatric hepatology; IQR, interquartile range