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Abstract(247 words)

Background: the restrictions imposed by the COVID-19 pandemic impact heavily the management of chronic diseases like asthma. This study aimed to evaluate the management of adults and children with asthma during COVID-19-related lockdown.

Methods: a survey was launched by the European Academy of Allergy and Clinical Immunology (EAACI) via e-mail, website and social media to EAACI members and members of peer societies.

Results: The survey was completed by 339 healthcare professionals from 52 countries. 79% of follow-up consultations were replaced by phone calls, whereas 49% of newly referred patients attended the clinic. 62%, 76%, 66%, 76% and 87% of responders did not conduct spirometry, impulse oscillometry, bronchodilator test, FeNO or methacholine provocation, respectively, for asthma diagnosis in adults. The numbers were similar for children. 73% of responders based the initial asthma diagnosis and the prescription of inhaled therapy on clinical parameters only. Lung function tests were used in 29% of cases to monitor asthma worsening and only 56% of participants recommended to their patients ambulatory peak expiratory flow (PEF) measurements. Using a 1 (not at all) to 5 (very much) scale, the responders considered that the quality of health care provided and the patients' asthma status had deteriorated during the lockdown with 3.2 points and 2.8 points, respectively.

Conclusion: Collectively, these results suggest that all necessary resources should be allocated to ensure the performance of lung function tests for initial diagnosis, whereas digital remote monitoring should be reinforced for the follow-up of children and adults with asthma.

Introduction

The COVID-19 pandemic challenges the capacity of healthcare systems to provide adequate management of chronic diseases [1-3]. Among other factors, discontinuation of face-to-face visits and the inability to perform diagnostic tests have a great impact on disease severity and degree of control [4]. A recent survey conducted by the Pediatric Asthma in Real Life (PEARL) think tank showed that the COVID-19 pandemic significantly impacts pediatric asthma services: 39%, 47% and 75% of them ceased physical appointments, stopped accepting new patients and limited patients' visits, respectively. Importantly, consultations were almost halved to a median of 20 patients per week, and virtual clinics and helplines were launched in most centers [5]. Another recent survey conducted among Chinese adult asthmatics reported that 75% of them did not attend any follow-up consultation since the beginning of the pandemic [6].

Both the initial diagnosis and subsequent monitoring of asthma largely rely on lung function tests (LFTs), which have a well-documented value and are required by all international guidelines [7]. Forced spirometry (FS), among other LFTs, have raised safety concerns, especially due to the potential generation of SARS-CoV-2-carrying bioaerosols [8]. Of note, the act of forced exhalation generates oral fluid droplets of variable size that can harbor infectious particles. Whereas large droplets fall quickly to the ground, small droplets can dehydrate and linger as bioaerosols in the air, thus functioning as vectors for viral transmission [9]. A recent study revealed that the mere pronunciation of the words "stay healthy" generates 227-347 droplets depending on the lung volume of the speaker [10].

To evaluate the impact of the lockdown restrictions related to COVID-19 pandemic on the management and health status of children and adults with asthma, the Asthma Section of the European Academy of Allergy and Clinical Immunology (EAACI) conducted a survey among EAACI members and members of other international scientific societies in July 2020. Of note, all countries around the world had been affected by the first wave of the pandemic at that moment [11].

Material & methods

Survey generation

The survey was generated by the authors. The specific topics on asthma management evaluated are listed in Appendix I in the online supplementary material.

Survey dissemination

The survey was launched on 1st July 2020 and remained open until 14th July 2020. The link to the survey was featured in the home page of EAACI website and was disseminated through a first mass e-mail to EAACI members (9343 contacts) on 1st July 2020 followed by a reminder mass e-mail on 13th July. The day the first mass e-mail was sent 2270 contacts (24%) opened the e-mail and 217 (10% of those who opened the e-mail) clicked the link heading to the survey. The link to the survey was also posted on EAACI and EAACI Junior Member official Facebook and Twitter accounts on 1st and 12th July 2020. Finally, the link was also shared with representatives from European Respiratory Society, American Academy of Allergy, Asthma and Immunology and World Allergy Organization who posted it in their social media channels at different time points during the days the survey remained open.

Instructions to reply to the survey

Because EAACI membership includes professionals who do not take care of asthma patients (basic scientists, dermatologists, ENT surgeons, dieticians, etc.), only clinicians and allied health professionals (e.g. nurses) totally or partially committed to adult and/or pediatric asthma were asked to reply to the survey. Moreover, the responders were instructed to refer to the hardest moment of the lockdown.

Results

Profile of the participants

Overall, 339 individuals from Europe (76%), America (18%), Asia (4%), Africa (2%) and Australia (0.3%) (52 different countries, see online supplementary material) participated in the survey, of whom 74% replied to all questions. The most frequent profile of the responder was an allergy specialist (60%), working in a University Hospital (36%) and taking care of both children and adults (41%) (**Figure 1**).

Availability of guidelines for asthma management during the pandemic

The survey first interrogated the participants for the availability of national guidelines on asthma management during COVID-19 pandemic. These documents existed in most countries (37 of 52), and 74%

of responders followed their recommendations. Nevertheless, 39% of participants were already following a similar approach before being aware of the guidelines.

Effect of the pandemic on the evaluation of asthma patients

During the lockdown, follow-up consultations were replaced by phone calls in 77% of cases, whereas only 49% of newly referred patients could attend the clinic in person. Of note, only in 10% of cases face-to-face visits were not somehow restricted (**Figure 2**). Regarding the performance of LFTs, 62%, 78%, 66%, 76% and 87% of responders who had the test available at their department did not conduct FS, impulse oscillometry (IOS), bronchodilator test (BDT), fractional exhaled nitric oxide (FeNO) measurement or airway hyperresponsiveness (AHR) tests (e.g. methacholine bronchial provocation), respectively, for asthma diagnosis in adults (**Figure 3A**). Similarly, 56%, 62%, 61% and 70% of participants with access to the tests did not use FS, IOS, BDT and AHR test for the diagnosis of pediatric asthma. The numbers were similar for the monitoring using LFT both for children and adults with asthma (**Figure 3B**). Importantly, 65% of participants did not conduct any LFT during the lockdown, and only in 15% of cases, more than one test per day and per device was performed.

Effect of the pandemic on asthma diagnosis and management

In a third step, the survey analyzed how asthma was managed during the pandemic. In 73% of cases, the physicians diagnosed asthma and prescribed inhaled therapy based on suggestive symptoms only (**Figure 4A**). Only 19% of participants conducted a full diagnostic workup for asthma diagnosis. Regarding patient monitoring, 69-72% of responders used only the current symptoms and the asthma history to adjust the treatment. LFTs were used in only 29% of cases to monitor patients reporting a clinical worsening (**Figure 4B**).

The survey particularly focused on the ambulatory measurement of peak expiratory flow (PEF), as this test can be performed using portable devices and can assist in monitoring asthma control, together with asthma symptoms, as part of a management plan [7, 8]. During the lockdown, 56% of responders encouraged their patients to conduct repeated ambulatory PEF measurements, while 41% considered PEF measurement not reliable for proper monitoring.

Asthma management after the end of the lockdown

When the survey was launched, restrictions associated with the first wave of the pandemic were loosening in many countries [11]. Therefore, the next step of the questionnaire evaluated the timeline to resume LFTs and the optimal strategy for future months. As per July 2020, only a minority of centers had

reinitiated LFTs (17-48% depending on the LFT type). Of note, in 53% of cases there was no specific timeline to resume AHR tests (**Figure 5A**). As for the remaining period of the pandemic, 63% of responders stated that LFTs should be restricted to selected patients, and only performed after the healthcare facilities have been adapted to the new safety requirements. Importantly, only 17% of participants believed that the number of LFTs should remain similar to that prior to the lockdown (**Figure 5B**).

Estimation of the effects of the lockdown on health indicators

In a last step of the survey, participants were asked to appreciate the deleterious impact of the pandemic on the management and evolution of asthma patients. Using a 1 (not at all) to 5 (very much) scale, the responders considered that both the quality of asthma related healthcare provided and the patients' asthma status had deteriorated during lockdown with 3.2 points and 2.8 points, respectively (**Figure 6**). Although 15-17% of participants considered that the quality of healthcare had decreased very much (5 of 5 points), only 6-7% identified a very important (5 of 5 points) worsening in the clinical condition of asthma patients. Nevertheless, the opinions of the responders were highly polarized as illustrated by the 41% and 22% of participants who scored the deleterious impact of the restrictions for LFT performance on patients' health status with 1 or 2 points and with 4 or 5 points, respectively.

Discussion

This EAACI Position Paper reports on a real-life situation experienced by physicians managing asthma patients during the first lockdown of the COVID-19 pandemic. Although a larger sample size would have been desirable, the number of survey participants is in line with previous multinational studies using a similar methodology [5, 12]. Even though national guidelines for asthma management during the pandemic existed in most countries, in many cases they were not crucial to determine the strategy to follow, as the responders were following the same approach before being aware of the guidelines. As previously reported [13], this observation probably reflects that most national documents were mainly based on expert-consensus just providing common sense recommendations that would be anyways implemented.

The survey reported that most patients referred for initial evaluation underwent phone consultations instead of face-to-face visits. Therefore, LFTs could not be performed and asthma diagnosis was guided only by clinical parameters. As previously demonstrated, this approach is associated with a significant rate of misdiagnosis and overtreatment with inhaled corticosteroids (ICS) [14, 15]. Importantly, ICS therapy is not indicated in all patients with COPD, a disease within the differential diagnosis of asthma. Of note, ICS therapy has been related to a higher risk of both bacterial pneumonia and bone fractures in COPD individuals [16, 17]. On the other hand, follow-up consultations were also conducted by phone calls in most cases. In this regard, the use of FS and FeNO measurement for the management of pediatric asthma has been associated with reduced exacerbation rates, among other beneficial outcomes [18, 19].

Existing evidence indicates that the ambulatory measurement of PEF, as part of a self-management plan, is useful to monitor the disease and decrease the rate of severe exacerbations in both children and adults with asthma [20-22]. Nevertheless, 41% of responders did not consider this test reliable, yet they acknowledged its additional safety guarantees as compared to LFTs conducted at healthcare facilities. Of note, adherence levels to PEF monitoring have been shown to be as low as 9% and PEF “diary fabrication” as high as 60% [23, 24]. One potential solution to overcome this limitation is the use of electronic PEF meters linked to smartphone apps allowing reminder notifications and immediate charting [25, 26]. In a real-life study, after a period of 6 months, 67% of asthma patients using electronic PEF meters measured their PEF at least once a week [27]. Besides facilitating LFT performance, e-health resources can help monitor symptoms and medication consumption, and can be used by patients to check their level of control [26]. Furthermore, e-health resources allow an immediate sharing of data with the treating physician, thus facilitating early therapeutic interventions and potentially preventing severe exacerbations [25].

The timeline to resume LFTs reflects the evolution of the pandemic worldwide, the precautions regarding the second wave and the availability of resources to adapt the healthcare facilities to the new situation [11]. Of note, most participants assumed that, given the circumstances, the best possible approach is to perform a reduced number of LFTs during the remaining months of the pandemic. This finding is probably connected with the moderate impact of the restrictions for LFTs performance (2.8-3.2 of 5 points) identified on average by the participants. This appreciation is also consistent with the results of previous studies on the topic. According to specialists in pediatric asthma, only 10% of patients experienced a clinical worsening during the pandemic [5], whereas only 8% of Chinese adult asthmatics believed that their clinical condition had aggravated during the lockdown [6]. Nevertheless, beyond the average score, EAACI survey also detected highly polarized opinions. This finding is probably explained by the evolving environment the pandemic is taking place in. On one hand, social distancing, sheltering at home, the use of face masks and the lockdown of workplaces and schools, might have reduced exposure to the main triggers of acute asthma symptoms such as rhinoviruses, outdoor seasonal allergens, physical exercise or ambient pollution during the first wave of the pandemic in Europe (March-June 2020) [28]. On the other hand, the high burden of indoor allergens (e.g. house dust mites) [29] during the second and subsequent waves (from October 2020 onwards in Europe) together with the lack of proper monitoring for the previous months, can be expected to increase uncontrolled asthma burden on healthcare systems in the future months. Our results are also consistent with the first international survey investigating practical aspects and tolerability of allergen immunotherapy (AIT) during the COVID-19 pandemic [30]. Although the responders expressed no concern of reduced safety of AIT in real-life circumstances, the survey showed a significant under-use of AIT during the pandemic. Although temporary, this phenomenon could be associated with a long-lasting negative impact on the clinical care of patients with airway allergy.

The EAACI survey indicates that beyond SARS-CoV-2 infection, the restrictions related to the lockdown significantly impact the quality of health care provided to asthma patients. Unlike previous studies focusing on specific age ranges or countries [5, 6], the EAACI survey reflects the impact of COVID-19 on adult and pediatric patients from different geographical areas. On the other hand, part of the data collected in EAACI survey is only indicative of the subjective appreciation of the responders. Moreover, similar to previous multinational surveys on allergy [5, 12], our study has a predominance of European responders, especially from Mediterranean countries. This finding likely reflects both the origin of EAACI membership and the regional differences in the implementation of Allergy specialty. In summary, given the well-established reliability of LFTs for asthma management [7, 13, 18-22], all necessary resources should be allocated to ensure the performance of LFTs for initial asthma diagnosis,

whereas PEF measurement should be reinforced for asthma tele-monitoring, both in children and in adults (supplementary table 1). In this regard, several national societies have recently published recommendations for safe lung function testing during the COVID-19 pandemic [31-34]. All these actions are necessary steps to guarantee the best possible health status of children and adults with asthma during present and future pandemics.

References:

1. Klimek L, Jutel M, Bousquet J, Agache I, Akdis C, Hox V, Gevaert P, Tomazic PV, Rondon C, Cingi C, Toppila-Salmi S, Karavelia A, Bozkurt B, Förster-Ruhrmann U, Becker S, Chaker AM, Wollenberg B, Mösges R, Huppertz T, Hagemann J, Bachert C, Fokkens W. Management of patients with chronic rhinosinusitis during the COVID-19 pandemic - An EAACI Position Paper. *Allergy*. 2020 [Online ahead of print]
2. Leonardi A, Fauquert JL, Doan S, Delgado L, Andant N, Klimek L, Bozkurt B. Managing ocular allergy in the time of COVID-19. *Allergy*. 2020;75(9):2399-2402.
3. Klimek L, Jutel M, Akdis C, Bousquet J, Akdis M, Bachert C, Agache I, Ansotegui I, Bedbrook A, Bosnic-Anticevich S, Canonica GW, Chivato T, Cruz AA, Czarlewski W, Del Giacco S, Du H, Fonseca JA, Gao Y, Haahtela T, Hoffmann-Sommergruber K, Ivancevich JC, Khaltayev N, Knol EF, Kuna P, Larenas-Linnemann D, Melen E, Mullol J, Naclerio R, Ohta K, Okamoto Y, O'Mahony L, Onorato GL, Papadopoulos NG, Pawankar R, Pfaar O, Samolinski B, Schwarze J, Toppila-Salmi S, Shamji MH, Teresa Ventura M, Valiulis A, Yorgancioglu A, Matricardi P, Zuberbier T; ARIA-MASK Study Group. Handling of allergen immunotherapy in the COVID-19 pandemic: An ARIA-EAACI statement. *Allergy*. 2020;75(7):1546-1554.
4. Bousquet J, Jutel M, Akdis CA, Klimek L, Pfaar O, Nadeau KC, Eiwegger T, Bedbrook A, Ansotegui IJ, Anto JM, Bachert C, Bateman ED, Bennoor KS, Berghea EC, Bergmann KC, Blain H, Bonini M, Bosnic-Anticevich S, Boulet LP, Brussino L, Buhl R, Camargos P, Canonica GW, Cardona V, Casale T, Chinthrajah S, Akdis M, Chivato T, Christoff G, Cruz AA, Czarlewski W, Del Giacco S, Du H, El-Gamal Y, Fokkens WJ, Fonseca JA, Gao Y, Gaga M, Gemicioglu B, Gotua M, Haahtela T, Halpin D, Hamelmann E, Hoffmann-Sommergruber K, Humbert M, Ilina N, Ivancevich JC, Joos G, Khaitov M, Kirenga B, Knol EF, Ko FW, Koskinen S, Kowalski ML, Kraxner H, Kudlay D, Kuna P, Kupczyk M, Kvedariene V, Abdul Latiff AH, Le LT, Levin M, Larenas-Linnemann D, Louis R, Masjedi MR, Melén E, Mihaltan F, Milenkovic B, Mohammad Y, Morais-Almeida M, Mullol J, Namazova L, Neffen H, Nunes E, O'Byrne P, O'Hehir R, O'Mahony L, Ohta K, Okamoto Y, Onorato GL, Panzner P, Papadopoulos NG, Passalacqua G, Patella V,

- Pawankar R, Pham-Thi N, Pigearias B, Popov TA, Puggioni F, Regateiro FS, Rolla G, Rottem M, Samolinski B, Sastre J, Schwarze J, Sheikh A, Scichilone N, Soto-Quiros M, Soto-Martinez M, Sova M, Nicola S, Stelmach R, Suppli-Ulrik C, Taborda-Barata L, To T, Tomazic PV, Toppila-Salmi S, Tsiligianni I, Usmani O, Valiulis A, Ventura MT, Viegi G, Vontetsianos T, Wang Y, Williams S, Wong GWK, Yorgancioglu A, Zernotti M, Zidarn M, Zuberbier T, Agache I. ARIA-EAACI statement on asthma and COVID-19 (June 2, 2020). *Allergy*. 2020. [Online ahead of print].
5. Papadopoulos NG, Custovic A, Deschildre A, Mathioudakis AG, Phipatanakul W, Wong G, Xepapadaki P, Agache I, Bacharier L, Bonini M, Castro-Rodriguez JA, Chen Z, Craig T, Ducharme FM, El-Sayed ZA, Feleszko W, Fiocchi A, Garcia-Marcos L, Gern JE, Goh A, Gómez RM, Hamelmann EH, Hedlin G, Hossny EM, Jartti T, Kalayci O, Kaplan A, Konradsen J, Kuna P, Lau S, Le Souef P, Lemanske RF, Mäkelä MJ, Morais-Almeida M, Murray C, Nagaraju K, Namazova-Baranova L, Garcia AN, Yusuf OM, Pitrez PMC, Pohunek P, PozoBeltrán CF, Roberts GC, Valiulis A, Zar HJ; Pediatric Asthma in Real Life Collaborators. Impact of COVID-19 on Pediatric Asthma: Practice Adjustments and Disease Burden. *J Allergy Clin Immunol Pract*. 2020;8(8):2592-2599.e3.
 6. Chang C, Zhang L, Dong F, Liang Y, Chen Y, Shang Y, Abulikemu M, Sun Y. Asthma control, self-management, and healthcare access during the COVID-19 epidemic in Beijing. *Allergy*. 2020 [Online ahead of print].
 7. The Global Initiative for Asthma (GINA) 2020 update: <https://ginasthma.org/> Last accessed 08.11.2020.
 8. Riggioni C, Comberiati P, Giovannini M, Agache I, Akdis M, Alves-Correia M, Antó JM, Arcolaci A, Azkur AK, Azkur D, Beken B, Boccabella C, Bousquet J, Breiteneder H, Carvalho D, De Las Vecillas L, Diamant Z, Eguluz-Gracia I, Eiwegger T, Eyerich S, Fokkens W, Gao YD, Hannachi F, Johnston SL, Jutel M, Karavelia A, Klimek L, Moya B, Nadeau KC, O'Hehir R, O'Mahony L, Pfaar O, Sanak M, Schwarze J, Sokolowska M, Torres MJ, van de Veen W, van Zelm MC, Wang Y, Zhang L, Jiménez-Saiz R, Akdis CA. A compendium answering 150 questions on COVID-19 and SARS-CoV-2. *Allergy*. 2020;75(10):2503-2541.
 9. Marr LC, Tang JW, Van Mullekom J, Lakdawala SS. Mechanistic insights into the effect of humidity on airborne influenza virus survival, transmission and incidence. *J R Soc Interface* 2019;16(150).
 10. Anfinrud P, Stadnytskyi V, Bax CE, Bax A. Visualizing Speech-Generated Oral Fluid Droplets with Laser Light Scattering. *N Engl J Med*. 2020;382(21):2061-2063.
 11. World Health Organization Coronavirus disease (COVID-19) pandemic: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019> Last accessed 08.11.2020.
 12. Caminati M, Antolín-Amérigo D, Bonini M, Buelow B, Bundy V, Couto M, Darlenski R, Fassio F, Kelly B, Kwong C, Santos A, Tsilochristou O, KaseTanno L; EAACI JMs Assembly Board, the AAAAI FIT

- Committee, the WAO Junior Members Steering Group. The EAACI-AAAAI-WAO Junior Members' joint survey: A worldwide snapshot of Allergy and Clinical Immunology specialty. *Allergy*. 2020;75(3):588-595.
13. Crimi C, Impellizzeri P, Campisi R, Nolasco S, Spanevello A, Crimi N. Practical considerations for spirometry during the COVID-19 outbreak: Literature review and insights. *Pulmonology*. 2020:S2531-0437(20)30175-6.
 14. LindenSmith J, Morrison D, Deveau C, Hernandez P. Overdiagnosis of asthma in the community. *Can Respir J*. 2004 Mar;11(2):111-6.
 15. McGrath KW, Fahy JV. Negative methacholine challenge tests in subjects who report physician-diagnosed asthma. *ClinExp Allergy*. 2011;41(1):46-51.
 16. Suissa S, Patenaude V, Lapi F, Ernst P. Inhaled corticosteroids in COPD and the risk of serious pneumonia. *Thorax*. 2013;68(11):1029-36.
 17. Gonçalves PA, Dos Santos Neves R, Neto LV, Madeira M, Guimarães FS, Mendonça LMC, Lopes AJ, Farias MLF. Inhaled glucocorticoids are associated with vertebral fractures in COPD patients. *J Bone Miner Metab*. 2018;36(4):454-461.
 18. Fielding S, Pijnenburg M, de Jongste JC, Pike KC, Roberts G, Petsky H, Chang AB, Fritsch M, Frischer T, Szeffler S, Gergen P, Vermeulen F, Vael R, Turner S. Change in FEV(1) and Feno Measurements as Predictors of Future Asthma Outcomes in Children. *Chest*. 2019;155(2):331-341.
 19. Cevhertas L, Ogulur I, Maurer DJ, Burla D, Ding M, Jansen K, Koch J, Liu C, Ma S, Mitamura Y, Peng Y, Radzikowska U, Rinaldi AO, Satitsuksanoa P, Globinska A, van de Veen W, Sokolowska M, Baerenfaller K, Gao YD, Agache I, Akdis M, Akdis CA. Advances and recent developments in asthma in 2020. *Allergy*. 2020 [Online ahead of print].
 20. Gibson PG, Wlodarczyk J, Hensley MJ, Murree-Allen K, Olson LG, Saltos N. Using quality-control analysis of peak expiratory flow recordings to guide therapy for asthma. *Ann Intern Med*. 1995;123(7):488-92.
 21. Fishwick D, Beasley R. Use of peak flow-based self-management plans by adult asthmatic patients. *EurRespir J* 1996;9(5):861-5.
 22. NICE guideline updates team (UK). Increasing ICS treatment within supported self-management for children and young people: Asthma: diagnosis, monitoring and chronic asthma management: Evidence review A. London: National Institute of Health and Care Excellence (UK); 2020 Feb.
 23. Garrett, J., Fenwick, J. M., Taylor, G., Mitchell, E. & Rea, H. Peak expiratory flow meters (PEFMs)—who uses them and how and does education affect the pattern of utilisation? *Aust. N. Z. J. Med*. 24, 521–529 (1994).

24. Côté J, Cartier A, Malo JL, Rouleau M, Boulet LP. Compliance with peak expiratory flow monitoring in home management of asthma. *Chest* 113, 968–972 (1998).
25. Elliott T, Shih J, Dinakar C, Portnoy J, Fineman S. American College of Allergy, Asthma & Immunology Position Paper on the Use of Telemedicine for Allergists. *Ann Allergy Asthma Immunol*. 2017 Dec;119(6):512-517.
26. Matricardi PM, Dramburg S, Alvarez-Perea A, Antolín-Amérigo D, Apfelbacher C, Atanaskovic-Markovic M, Berger U, Blaiss MS, Blank S, Boni E, Bonini M, Bousquet J, Brockow K, Buters J, Cardona V, Caubet JC, Cavkaytar Ö, Elliott T, Esteban-Gorgojo I, Fonseca JA, Gardner J, Gevaert P, Ghiordanescu I, Hellings P, Hoffmann-Sommergruber K, FusunKalpaklioglu A, Marmouz F, MeijideCalderón Á, Mösges R, Nakonechna A, Ollert M, Oteros J, Pajno G, Panaitescu C, Perez-Formigo D, Pfaar O, Pitsios C, Rudenko M, Ryan D, Sánchez-García S, Shih J, Tripodi S, Van der Poel LA, van Os-Medendorp H, Varricchi G, Wittmann J, Worm M, Agache I. The role of mobile health technologies in allergy care: An EAACI position paper. *Allergy*. 2020;75(2):259-272.
27. Antalffy T, De Simoni A, Griffiths CJ. Promising peak flow diary compliance with an electronic peak flow meter and linked smartphone app. *NPJ Prim Care Respir Med*. 2020;30(1):19.
28. Gallo O, Bruno C, Orlando P, Locatello LG. The impact of lockdown on allergic rhinitis: What is good and what is bad? *LaryngoscopeInvestigOtolaryngol*. 2020;5(5):807-808.
29. Eguiluz-Gracia I, Mathioudakis AG, Bartel S, Vijverberg SJH, Fuertes E, Comberiati P, Cai YS, Tomazic PV, Diamant Z, Vestbo J, Galan C, Hoffmann B. The need for clean air: The way air pollution and climate change affect allergic rhinitis and asthma. *Allergy*. 2020;75(9):2170-2184.
30. Pfaar O, Agache I, Bonini M, Brough HA, Chivato T, del Giacco SR, Gawlik R, Gelincik A, Hoffmann-Sommergruber K, Jutel M, Klimek L, Knol EF, Lauerma A, Ollert M, O'Mahony L, Mortz CG, Palomares O, Riggioni C, Schwarze J, Skypala I, Torres MJ, Untersmayr E, Walusiak-Skorupa J, Chaker A, Giovannini M, Heffler E, Jensen-Jarolim E, Quecchia C, Sandoval-Ruballos M, Sahiner U, TomicSpiric V, Alvaro-Lozano M. COVID-19 pandemic and allergen immunotherapy-an EAACI survey. *Allergy* 2021. *In press*.
31. Olaguibel JM, Alobid I, Alvarez Puebla M, Crespo-Lessmann A, Domínguez Ortega J, García-Rio F, Izquierdo-Domínguez A, Mullol J, Plaza V, Quirce S, Rojas-Lechuga MJ, Valvere-Monge M, Sastre J. Upper and Lower Airways Functional Examination in Asthma and Respiratory Allergic Diseases. Considerations in the SARS-CoV-2 Post-Pandemic Situation. *J InvestigAllergolClinImmunol*. 2020 [Online ahead of print].
32. Franczuk M, Przybyłowski T, Czajkowska-Malinowska M, Radliński J, Bochenek G, Wesołowski S, Sliwiński P. Spirometry during the SARS-CoV-2 pandemic. Guidelines and practical advice from the

expert panel of Respiratory Physiopathology Assembly of Polish Respiratory Society. *Adv Respir Med.* 2020;88(6):640-650.

33. Bignamini E, Cazzato S, Cutrera R, Ferrante G, La Grutta S, Licari A, Lombardi E, Midulla F, Piacentini G, Pifferi M, Santamaria F, Tancredi G, Turchetta A; Italian Pediatric Respiratory Society (IPRS) Committee Members. Italian pediatric respiratory society recommendations on pediatric pulmonary function testing during COVID-19 pandemic. *Ital J Pediatr.* 2020;46(1):68.
34. Gemicioğlu B, Börekçi Ş, Dilektaşlı AG, Ulubay G, Azap Ö, Saryal S. Turkish Thoracic Society Experts Consensus Report: Recommendations for Pulmonary Function Tests During and After COVID 19 Pandemic. *Turk Thorac J.* 2020;21(3):193-200.

Figure legends:

Figure 1: Features of the individuals participating in the survey in relation to scientific society membership (A), medical specialty (B), working environment (C) and type of patient taking care of (D). The numbers besides/above the bars indicate the proportion of participants who selected the different options. Figure 1E shows in red color the countries of practice of the participants. EAACI: European Academy of Allergy and Clinical Immunology.

Figure 2: Impact of the restrictions related to COVID-19 pandemic on the medical visit of asthma patients. The numbers besides the bars indicate the proportion of participants who selected the different options.

Figure 3: Performance of lung function tests during the pandemic. The numbers above the bars indicate the proportion of participants who selected the different options. FeNO: fractional exhaled nitric oxide; AHR test: airway hyper-responsiveness test (e.g. methacholine bronchial challenge); PEF: peak expiratory flow.

Figure 4: Asthma management during the COVID-19 pandemic. The numbers besides the bars indicate the proportion of participants who selected the different options.

Figure 5: Timeline to resume lung function testing during the COVID-19 pandemic (A) and approach suggested by the participants in relation to the performance of lung function tests during the remaining months of the pandemic (B). The numbers above/besides the bars indicate the proportion of participants who selected the different options. FeNO: fractional exhaled nitric oxide; AHR test: airway hyper-responsiveness test (e.g. methacholine bronchial challenge).

Figure 6: Impact of the restrictions related to COVID-19 pandemic (face-to-face visits and test performance) on the quality of health care provided and the health status of asthma patients. The numbers above the bars indicate the proportion of participants who selected the different options.

Figure 1

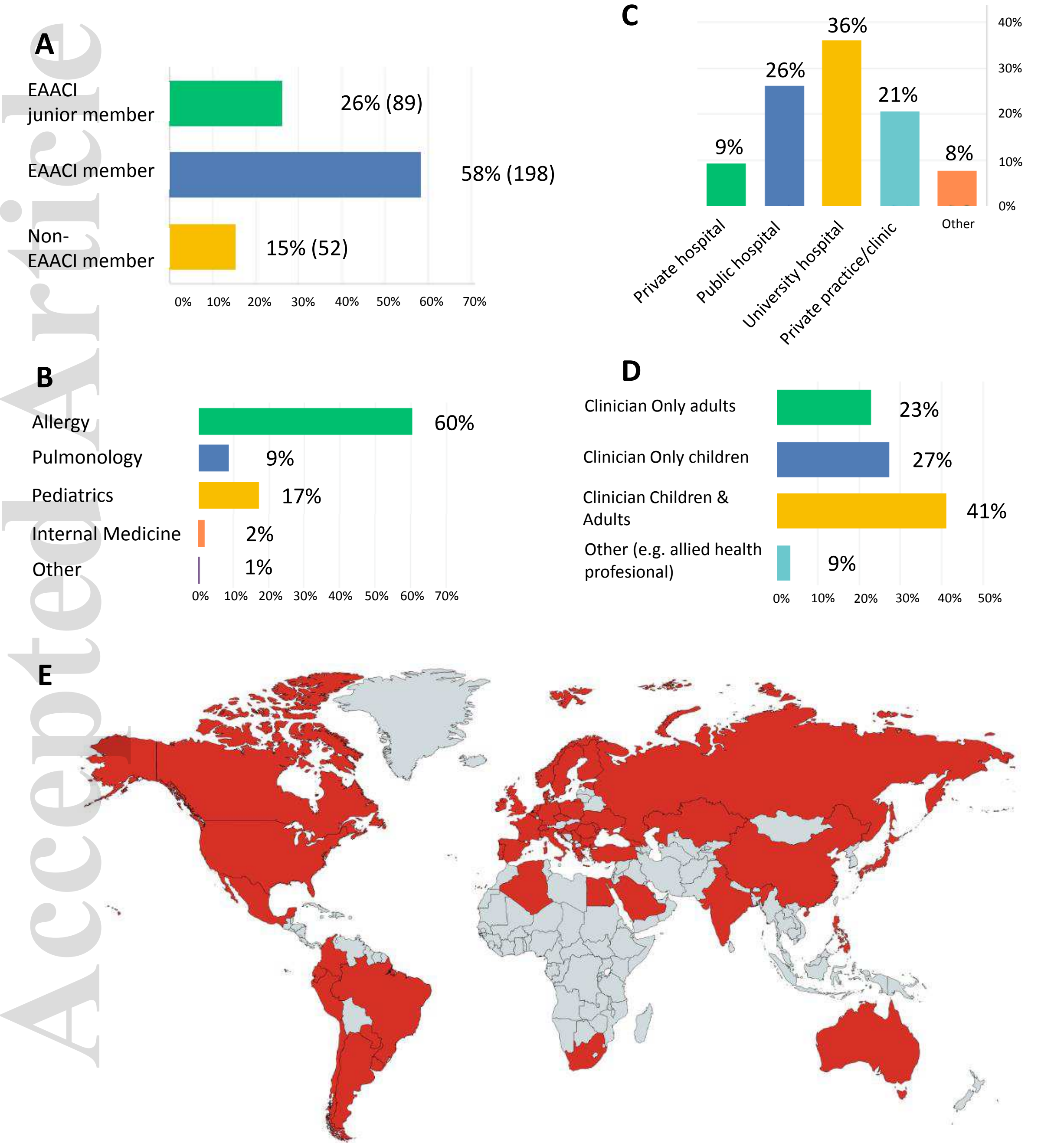


Figure 2

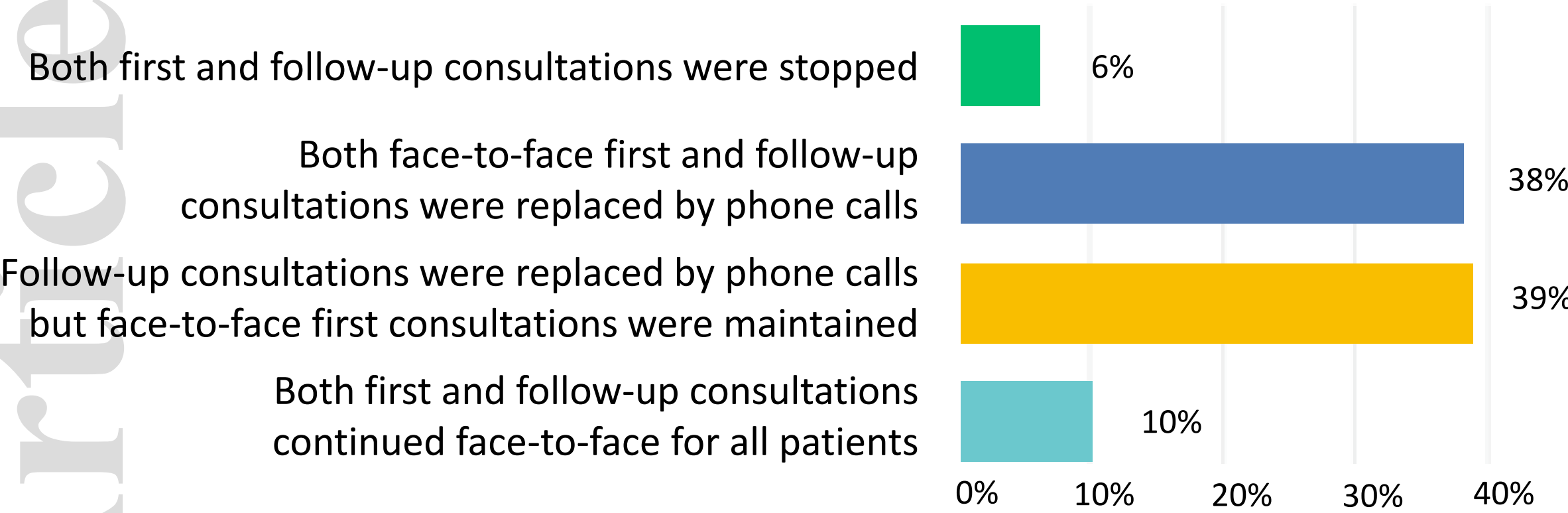
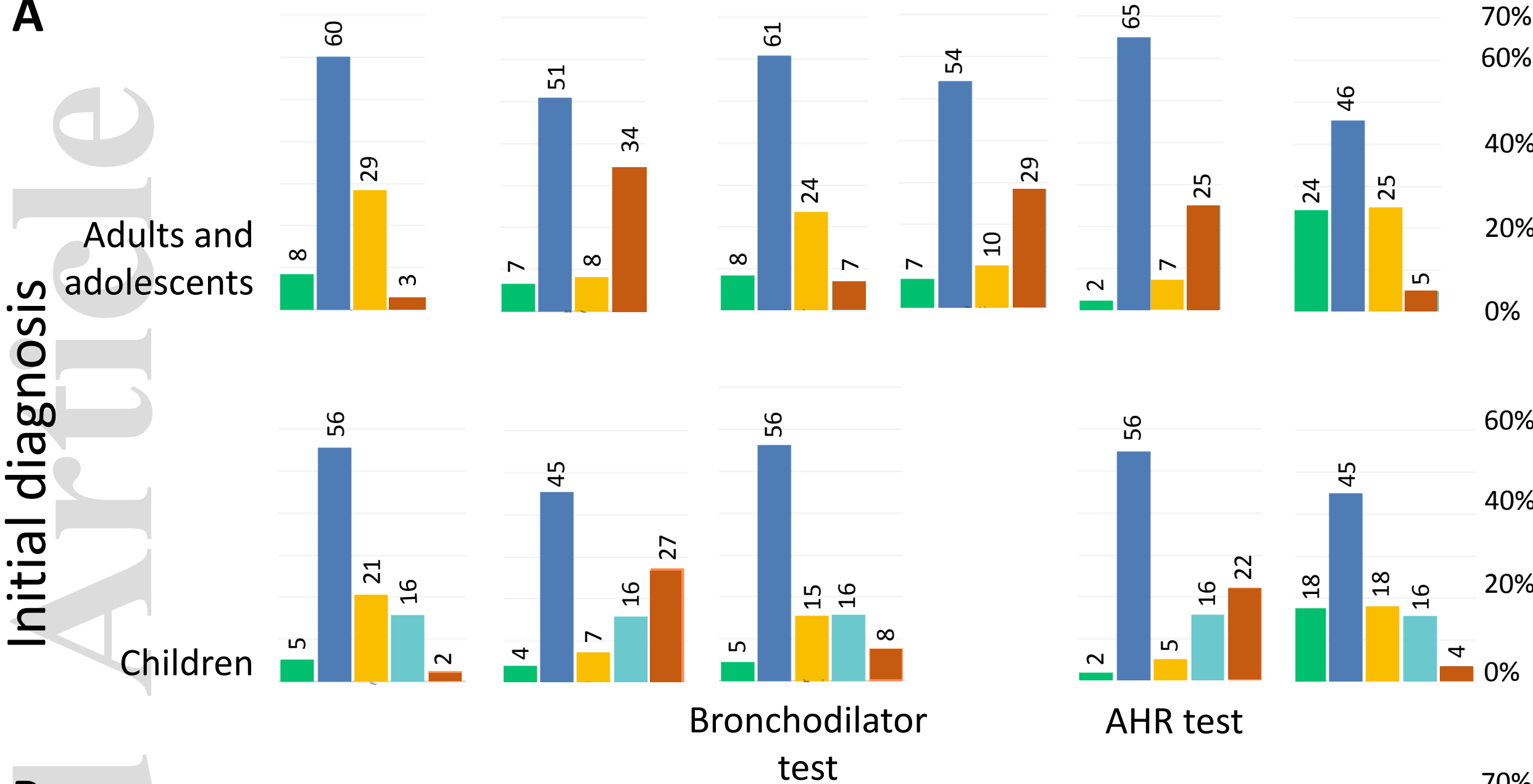


Figure 3

A



B

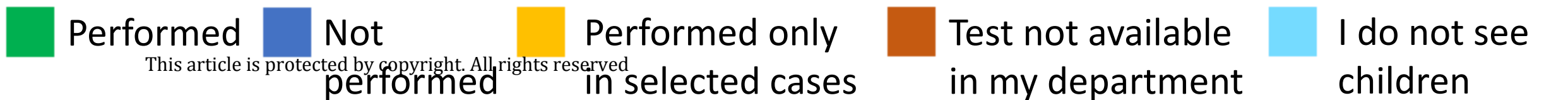
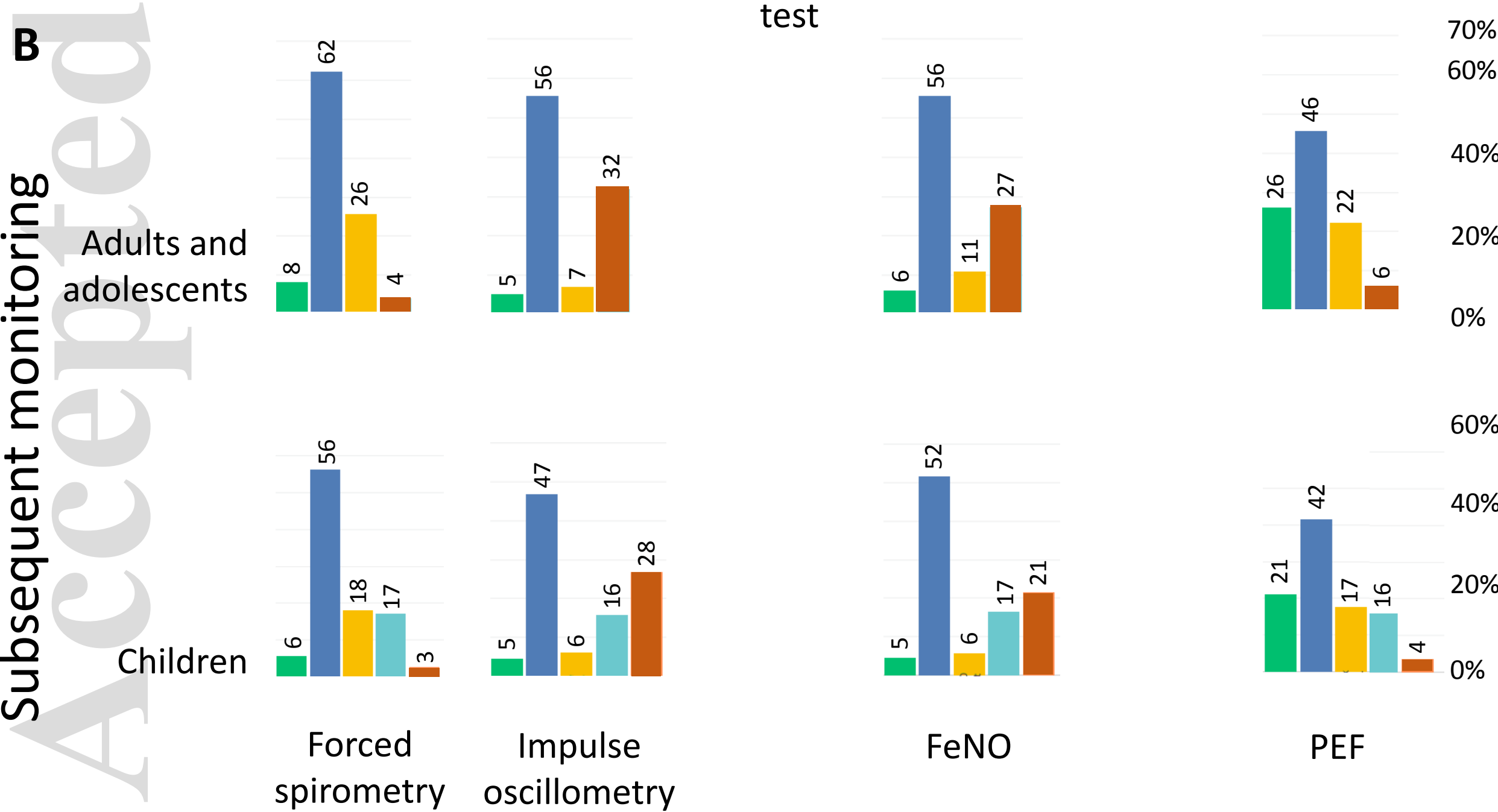


Figure 4

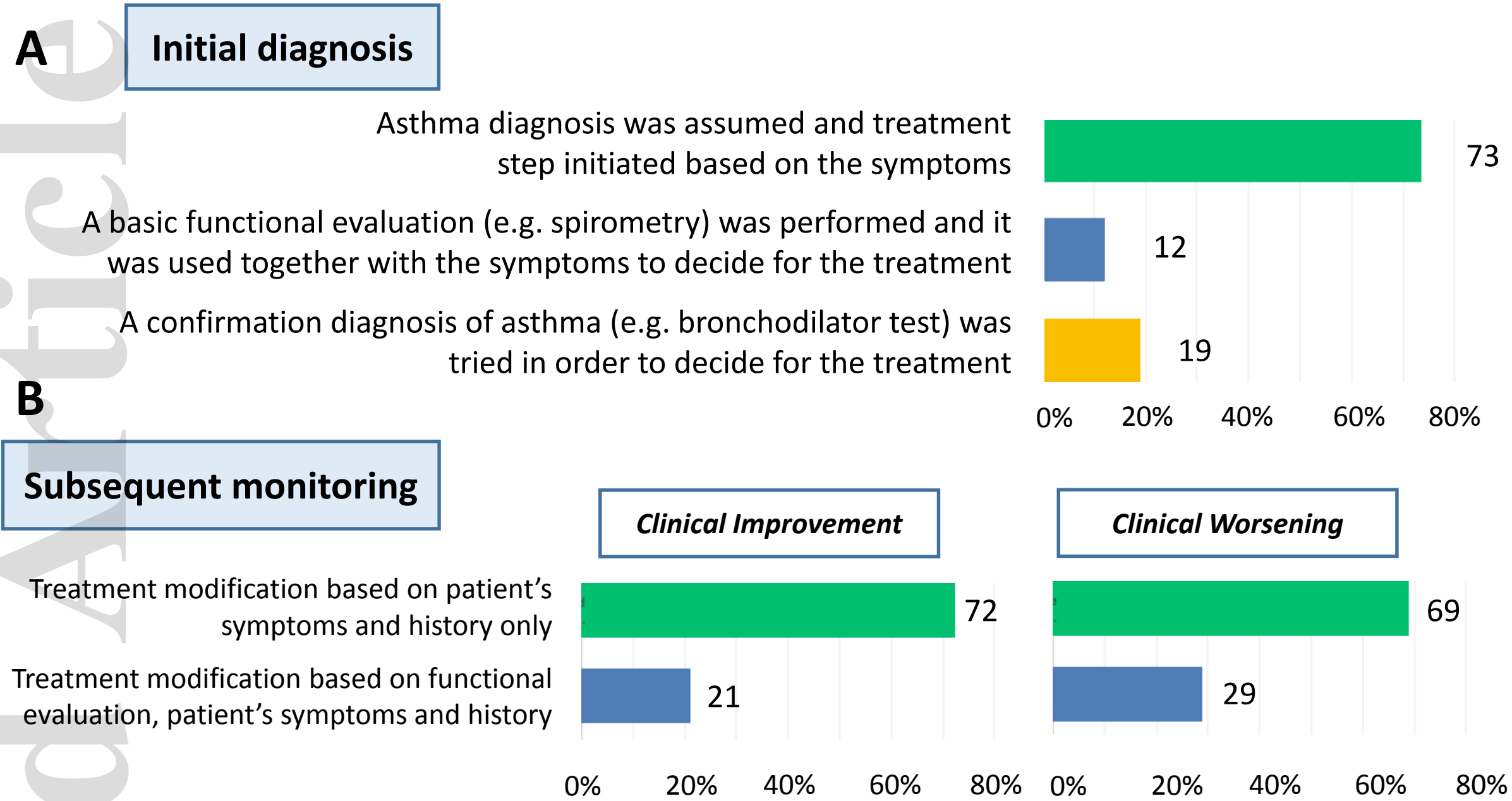


Figure 5

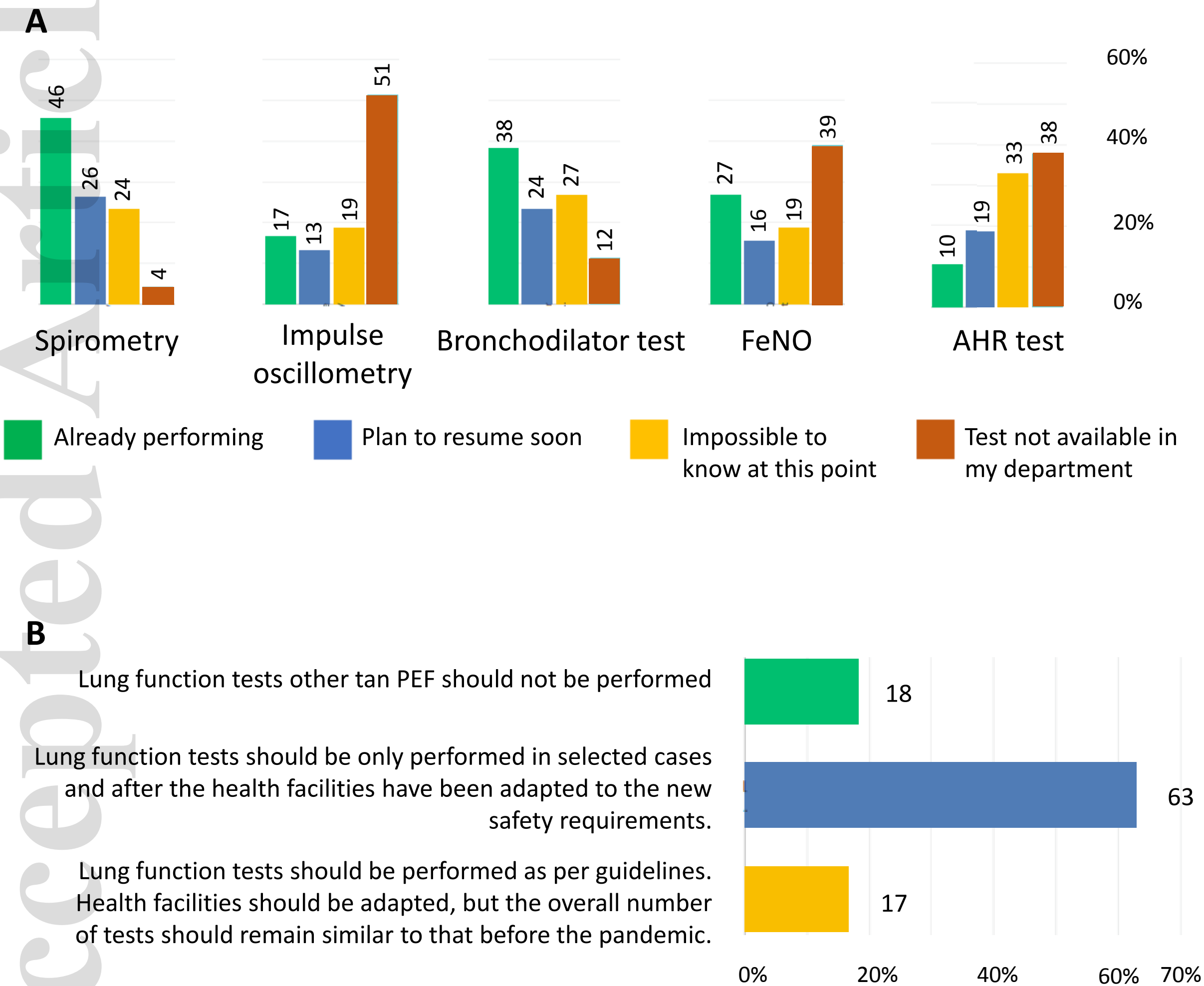


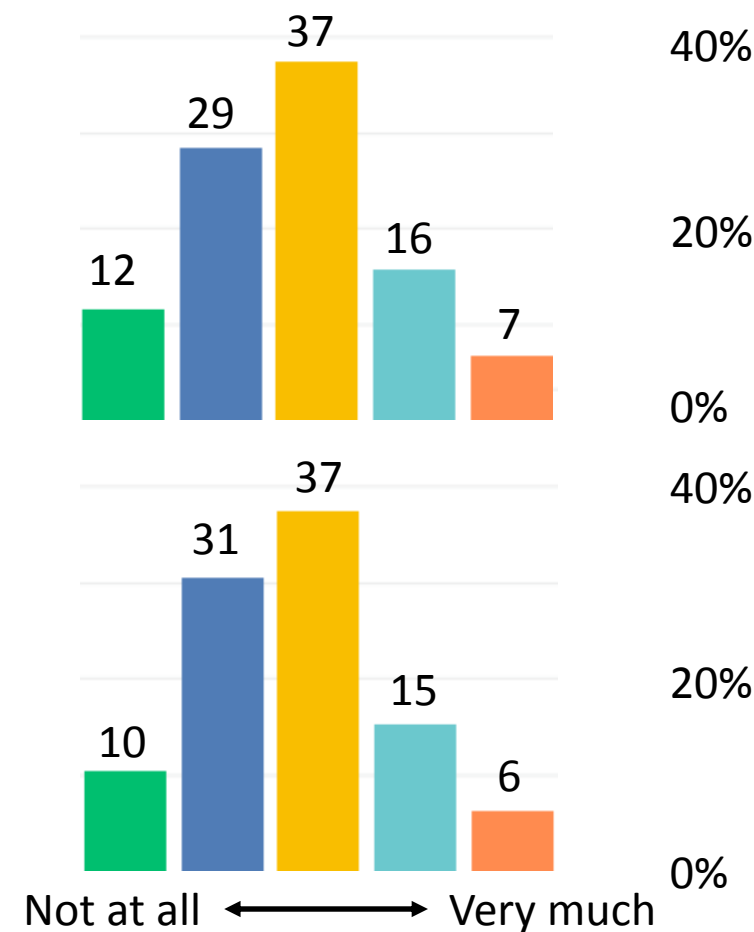
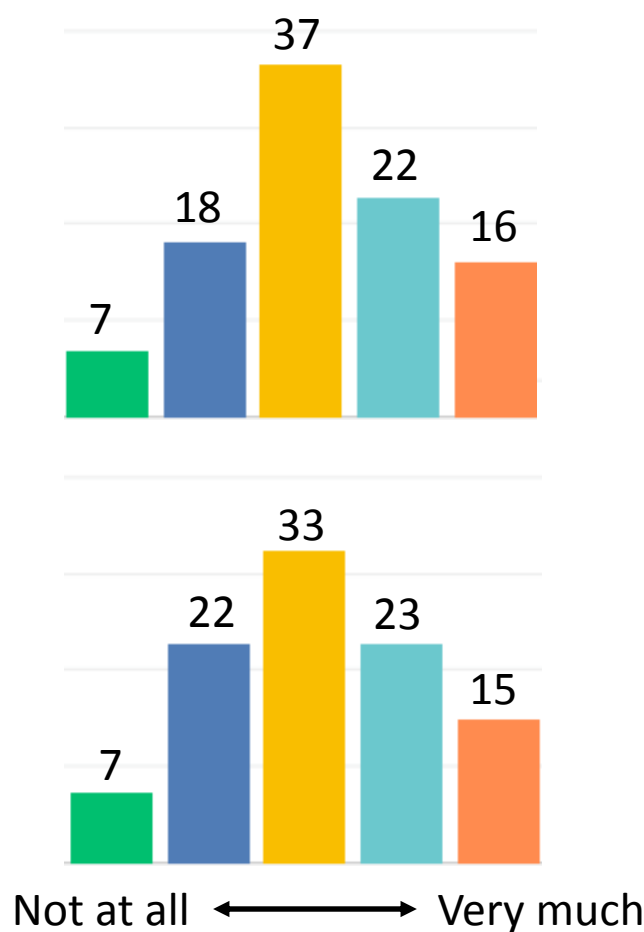
Figure 6

Restrictions for
face-to-face visits

Restrictions for
test performance

Decrease of the quality
of health care provided

Worsening in the clinical
condition of patients



Online supplementary material

Title: Real-life impact of COVID-19 pandemic lockdown on the management of pediatric and adult asthma: a survey by the EAACI Asthma Section

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37 Country distribution of the participants in the survey (number of responders)

38 Albania (6), Algeria (1), Argentina (1), Australia (1), Bahrain (1), Belgium (1), Brazil (14), Bulgaria
39 (4), Canada (6), Chile (1), China (3), Colombia (5), Croatia (1), Czech Republic (3), Denmark (3),
40 Ecuador (1), Egypt (3), Estonia (1), Finland (1), France (5), Georgia (3), Germany (8), Greece (14),
41 Hungary (2), India (6), Ireland (1), Italy (18), Japan (5), Kazakhstan (2), Mexico (16), Moldova (1),
42 The Netherlands (1), Norway (1), Paraguay (2), Peru (1), Philippines (1), Poland (8), Portugal (56),
43 Romania (12), Russia (14), Saudi Arabia (2), Serbia (9), Slovenia (1), South Africa (3), Spain (42),
44 Sweden (2), Switzerland (3), Turkey (17), Ukraine (1), United Kingdom (8), Uruguay (1), United
45 States of America (6).

46 Appendix I (questions & answers in the survey)

47 **Q1:** What is your EAACI membership status? *Replied by 339/339.*

- 48 1. EAACI Junior Member
49 2. EAACI Member
50 3. Non-EAACI member

51 **Q2:** What is your professional activity? *Replied by 339/339.*

- 52 1. Clinician completely or partially committed to asthma care_adult patients
53 2. Clinician completely or partially committed to asthma care_pediatric patients
54 3. Clinician completely or partially committed to asthma care_adult and pediatric patients
55 4. Allied health professional completely or partially committed to asthma care

56 **Q3:** What is the country where you develop your professional activity? *Replied by 339/339.*

57 Free choice from a panel

58 **Q4:** What is your specialization? *Replied by 326/339.*

- 59 1. Allergy
60 2. Pulmonology
61 3. Pediatrics
62 4. Sports Medicine
63 5. Internal Medicine
64 6. Others

65 **Q5:** Are there any national guidelines for the management of asthma patients during the COVID-
66 19 pandemic available in your country? *Replied by 326/339.*

- 67 1. Yes
68 2. No
69 3. I do not know

Q6: Do you follow any national or international (e.g. WHO) guideline for the management of asthma patients during the COVID-19 pandemic in your clinical department? *Replied by 326/339.*

1. Yes, they were helpful to decide for the best strategy to follow
2. Yes, but we were already following a similar strategy before being aware of the guidelines
3. No, we followed a different strategy
4. I do not know

Q7: Please, select the applied option related to health care provided to patients with suspected or confirmed asthma during COVID-19 lockdown. *Replied by 284/339.*

1. To stop both first and follow-up consultations
2. To replace face-to-face visits by phone calls for all patients
3. To replace face-to-face visits by phone calls for follow-up consultations, but to maintain face-to-face visits for newly referred patients.
4. To maintain face-to-face visits for all patients
5. Other (please, specify)

Q8: Did you perform the following tests for asthma diagnosis in adults and adolescents during the COVID-19 lockdown? *Replied by 284/339.*

For each test Yes/No/Only in selected cases/I do not have this exam available

1. Spirometry
2. Impulse oscillometry
3. Bronchodilator test with spirometry and/or impulse oscillometry
4. FeNO measurement
5. Methacholine bronchial challenge or equivalent
6. Peak expiratory flow variability over time

Q9: Did you perform the following tests for asthma diagnosis in children during the COVID-19 lockdown? *Replied by 284/339.*

For each test Yes/No/Only in selected cases/I do not see children/I do not have this exam available

1. Spirometry
2. Impulse oscillometry
3. Bronchodilator test with spirometry and/or impulse oscillometry
4. Methacholine bronchial challenge or equivalent
5. Peak expiratory flow variability over time

Q10: Did you perform the following tests for asthma management in adults and adolescents during the COVID-19 lockdown? *Replied by 284/339.*

For each test Yes/No/Only in selected cases/I do not have this exam available

1. Spirometry
2. Impulse oscillometry
3. FeNO measurement
4. Personal peak expiratory flow device

Q11: Did you perform the following tests for asthma management in children during the COVID-19 lockdown? *Replied by 284/339.*

For each test Yes/No/Only in selected cases/I do not see children/I do not have this exam available

1. Spirometry
2. Impulse oscillometry
3. FeNO measurement
4. Personal peak expiratory flow device

Q12: During the COVID-19 lockdown, how many tests (spirometry, oscillometry or FeNO measurement) did you perform per day and per device? *Replied by 284/339.*

1. None
2. 1 test per device per day
3. >1 test per device per day

Q13: During the COVID-19 lockdown, which of the following approaches did you preferentially follow to decide the initial treatment for patients referred to your clinic with a clinical history suggestive of asthma? *Replied by 264/339.*

1. To assume asthma diagnosis and to decide treatment step based on the frequency and severity of symptoms.
2. To perform an on-site basic functional evaluation (e.g. spirometry) which was used, together with the frequency and severity of symptoms, to decide for the initial treatment step
3. To confirm asthma diagnosis and thereafter choose the treatment step based on the frequency and severity of symptoms.
4. Other (please, specify)

Q14: During the COVID-19 lockdown, which of the following approaches did you preferentially follow to decide the treatment of asthmatic patients with a significant improvement of their clinical condition? *Replied by 264/339.*

1. To change the treatment based on the patient's symptoms and the asthma history only
2. To perform, as per guidelines, functional evaluation which was used, together with the symptoms frequency and severity and the patient's asthma history, to decide for the change in treatment step
3. Other (please, specify)

Q15: During the lockdown related to COVID-19 pandemic, which of the following approaches did you preferentially follow to decide for the treatment of asthmatic patients with a significant worsening of the clinical condition? *Replied by 264/339.*

1. To change the treatment based on patient's symptoms and the asthma history only
2. To perform, as per guidelines, functional evaluation which was used, together with the symptoms frequency and severity and the patient's asthma history, to decide for the change in treatment step
3. Other (please, specify).

Q16: Do you agree or disagree with the following statements in relation to the use of peak expiratory flow (PEF) during the COVID-19 pandemic. *Replied by 251/339.*

For each one select agree/disagree.

1. It is a very good option, as the use of personal PEF devices poses significantly less safety concerns than other methods. I widely used PEF records for asthma diagnosis and management in my clinic during the last months.
2. It is a very good option, as the use of personal PEF devices poses significantly less safety concerns than other methods. Nevertheless, due to logistical reasons, I was not able to use PEF records to take clinical decisions during the last months.
3. Even though PEF records are safer than other methods, I believe they are not functional for the daily clinic.

Q17: Most European countries are currently under the de-escalation phase of the COVID-19 lockdown. When will you start performing the following tests used in asthma diagnosis and management? *Replied by 251/339.*

For each option select: Already performing/Plan to resume soon/Impossible to know at this point/Test not performed in my department

1. Spirometry
2. Impulse oscillometry
3. Bronchodilator test with spirometry and/or impulse oscillometry
4. FeNO measurement
5. Methacholine bronchial challenge or equivalent
6. Bronchial allergen challenge

Q18: If the risk for SARS-CoV-2 transmission persists for the second half of 2020, which of the following approaches would you consider more adequate for the diagnosis and management of asthma patients? *Replied by 251/339.*

1. As a general rule, lung function tests other than self-measured PEF should not be performed as they pose an unacceptable risk for patients and health care providers.
2. Clinical departments should adapt a facility to perform lung function tests (e.g. an isolated room) to decrease the chances of transmission. Lung functions tests should be limited to severe or selected cases.
3. As a general rule, lung function tests should be performed as per guidelines. Wherever possible, the clinical facilities should be adapted to decrease the chance of transmission, but the overall number of lung function tests should remain similar to that before the COVID-19 pandemic.
4. Other (please, specify).

Q19: In your opinion, how much have the restrictions for face-to-face visits worsened the quality of health care provided to asthma patients during the COVID-19 pandemic? *Replied by 249/339.*

Please, grade from 1 (nothing at all) to 5 (very much)

Q20: In your opinion, how much have the restrictions for test performance worsened the quality of health care provided to asthma patients during the COVID-19 pandemic? *Replied by 249/339.*

Please, grade from 1 (nothing at all) to 5 (very much)

Q21: In your opinion, how much have the restrictions for face-to-face visits worsened the clinical condition (e.g. degree of control) of asthma patients during the COVID-19 pandemic? *Replied by 249/339.*

Please, grade from 1 (nothing at all) to 5 (very much)

Q22: In your opinion, how much have the restrictions for test performance worsened the clinical condition (e.g. degree of control) of asthma patients during the COVID-19 pandemic? *Replied by 249/339.*

Please, grade from 1 (nothing at all) to 5 (very much)

Supplementary Table 1: Summary of unmet needs for the management of asthma patients during COVID-19 pandemic, based on the analysis of EAACI Asthma Section Survey

	Unmet need
For initial asthma diagnosis	To perform lung function tests, especially spirometry with bronchodilator test*.
For subsequent follow-up of asthma patients	To reinforce tele-monitoring and encourage peak expiratory flow (PEF) measurement using personal and portable devices.

*To this end, existing guidelines for safe lung function testing during COVID-19 pandemic should be followed.