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Brief Communication

Uncharted territory: challenges and opportunities in pediatric sleep medicine during the COVID-19 pandemic and beyond part II: the sleep laboratory

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1. Introduction

Among the myriad of changes in pediatric sleep medicine resulting from the COVID-19 pandemic, perhaps none were more substantial and impactful than those affecting the delivery of diagnostic and treatment services in the sleep laboratory setting. The American Academy of Sleep Medicine (AASM) guided by Center for Disease Control (CDC) recommendations, and the American Thoracic Society (ATS) have published guidelines for reopening sleep laboratories, but most of these were general and lacked specific recommendation based on challenges unique to pediatric sleep centers [1,2]. However, it is likely that many of the clinical, administrative, and technical adaptations related to the pandemic will result in permanent changes to policies and procedures in sleep labs that study children and adolescents. This clearly has implications for future practice and thus presents a need for further examination of the challenges encountered and of the relative pros and cons of a variety of response options [3], as well as offering an opportunity for ongoing dialogue and collaboration among our pediatric sleep medicine colleagues in the US and around the globe.

2. Pediatric sleep laboratory operation during and beyond the pandemic

During much of 2020, pediatric and mixed adult sleep labs in the US and around the world were closed or operated on a limited capacity, thus significantly reducing the ability to accurately diagnose and manage sleep disorders in children. As the COVID cases began trending down in some locations, individual institutions established re-entry plans based on institutional, local, state, and federal and government guidelines. However, most of these general guidelines lacked specific recommendations regarding stand-alone pediatric sleep laboratories, particularly those serving children with various complex and chronic disorders. Thus, a number of challenges arose, including:

- *Requirements for COVID testing* for patients and caregivers prior to conducting a *routine* sleep study. Indications for COVID testing has varied across different institution in the US and abroad. For example, at some hospitals, if answers to a short series of COVID screening questions administered by the sleep lab scheduling staff were negative within 48 h of a scheduled study, routine COVID testing of patients and caregivers was not required. In most institutions, all inpatients were COVID tested on admission. However, the testing protocols in other sleep labs varied widely, with some requiring mandatory testing of all patients and the accompanying caregiver as well. This level of variability, while in part reflecting availability of testing and local infection rates, suggests that in the future, a more standardized approach informed by the evidence gathered during this pandemic will be critical. In particular, it will continue to be vital to track and report COVID infection in any staff or patient/caregiver related to undergoing an in-lab sleep study across the US and globally.
- For studies at risk for *aerosolized generating procedures* such as open tracheostomy sleep studies, and positive airway pressure

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(PAP) and ventilation titration studies, in many institutions negative COVID testing within 48 h was required. At some institutions, caregivers have not been allowed to use their PAP therapy during their child's sleep study. In this case, if an alternative accompanying caregiver is not available or if there is no separate bedroom accommodation for parents in the lab, caregiver COVID testing within 72 h prior to the study was a strategy employed in some sleep centers.

- *Phased-in approach:* A gradual phase-in has been critical in identifying issues in the various logistics, triage process, workflow, and systems that needed adjustment as well as system errors while allowing for ample opportunity to learn and address these issues before further ramping up volume. Overarching issues included development and later refinement of inclusion and exclusion criteria for eligible patients based on need, and local resources and support. Potential roadblocks to full implementation have included staffing limitations due to the need for a 1:1 patient to technologist ratio, maintaining appropriate social distancing, caregivers' reluctance to bring their children into the hospital setting for a sleep study, and a continued decline in referrals from major provider sources such as otolaryngologists For example, although anecdotal, discussions with ORL surgeons in our institution and in the local community during the early part of the pandemic suggested that relatively straight forward uncomplicated patients who needed adenotonsillectomies were often taken directly to surgery without a sleep study, due to multiple factors such as sleep lab operations working at limited capacity, longer wait times, or caregiver's hesitation.
- *Cost factors:* One of the unintended consequences of a phased-in approach has been a rise in the relative cost of pediatric sleep studies related to such variables as use of disposable supplies, modifications in the lab such as installation of plexiglass barriers, reduced bed capacity and lower sleep study referral volume. These issues may pose an additional economic burden for many institutions performing pediatric studies through late 2021–2022.
- *Balancing backlog and increasing number of referrals.* Alternatively, many labs are now experiencing a surge in referrals as referring providers ramp up their clinic volumes. In addition, many face a significant backlog of non-urgent patients that were cancelled during the pandemic. It is critical to contact, track and document the status of all of these patients, including those who have already undergone testing or treatment or are no longer symptomatic, or need to be triaged and rescheduled.

2.1. Opportunities during the COVID pandemic

This pandemic has also provided an unprecedent opportunity to develop and trial interventions which were infrequently or not used in children, leading to possibilities for innovation and adoption of some novel clinical strategies (Table 1).

- *Auto-Continuous Positive Airway Pressure (CPAP) use in children*: Many children with moderate-severe obstructive sleep apnea (OSA) for whom there was no surgically treatable lesion, or with limited access to surgery due to the pandemic, were empirically started on auto-CPAP. While there are a few studies documenting utility of auto-CPAP in older children [4,5], the pandemic has provided an opportunity to expand its clinical application. Furthermore, mask fittings were initially discontinued at many institutions; however new approaches such as 3D face photography to identify appropriate mask type and size and 3D printing to produce a custom fit mask represent an opportunity to utilize technology to improve patient care.

Table 1
Lessons learned: Opportunities and considerations for pediatric sleep labs post-COVID-19.

A. New opportunities during COVID pandemic
- Use of Auto-CPAP in children
- Home sleep studies for selected groups of children and adolescents
- Telemedicine: CPAP clinic, and teleconferences for teaching fellows, sleep technicians
- Consideration for separate accreditation/certification standards for sleep labs that study children
B. Considerations for construction and renovation of pediatric sleep labs in the future
- Each sleep room built with attached bathroom (avoid sharing)
- Incorporate negative pressure in sleep rooms
- Air conditioning and heating should avoid circulating air between different rooms
- Each room has its own oxygen, and suctioning port
- Each room has space/cabinets to stock supplies: reduce risk for cross contamination
- Sleep lab control room built with each workstation at least 6 feet apart and plexiglass barriers between each station
- Use of ultraviolet C light technology for sterilization of sleep room after use

- *Home Sleep Apnea Testing (HSAT):* The pandemic has also offered an expanded opportunity for evaluating the feasibility and validity of HSAT in the pediatric population Although these devices have limitations, especially in younger age groups and in those patients with high risk and high pre-test probability (eg, obesity), studies suggest that HSAT may be feasible in selected pediatric patients [6,7]. There are several Level 3 ambulatory sleep study devices currently used in adults including the Watch-PAT device, which is FDA approved for adolescents. The hope is that validation studies coupled with increasing clinical experience in a variety of pediatric populations as well as refinement of the triaging process to identify appropriate pediatric candidates will ultimately provide providers and payors with the evidence needed to utilize these emerging technologies.
- *Telemedicine and teleconference*: While some laboratory operations were already being performed remotely (eg, monitoring sleep study acquisition, scoring, and reading), in the future, use of artificial intelligence to refine and expedite scoring holds great promise. In addition, “tele-training” with sleep technologists can lead to more interactions between staff and technologists. “Virtual tours” of the sleep lab with an experienced technologist offers convenience to families while providing an opportunity to both patient and caregiver to ask questions, potentially reducing “no show” rates in the lab, and also allowing for some direct assessment of patient's anxiety level and any anticipated behavioral concerns. Another metric to closely monitor is patient satisfaction and quality of care delivered via virtual visit platforms with new quality improvement initiatives.
  Telemedicine is also ideally suited to CPAP follow up, allowing for more frequent patient contacts and adjustments to behavioral management strategies, especially when coupled with frequent remote CPAP data collection for monitoring compliance and efficacy and for making pressure adjustments and direct visualization of mask fit.
- *Requirements for labs performing pediatric studies:* The unique challenges during the pandemic also helped to underscore the paucity in general of specific guidelines for managing pediatric patients in “mixed” adult sleep labs. Furthermore, while there is some overlap, applying adult sleep center guidelines to exclusively pediatric centers may not be appropriate, given the unique challenges and logistical issues in performing sleep studies, often in medically-complex children. These “lessons

learned" during the pandemic may provide an opportunity to re-visit the requirements for both mixed and pediatric labs that establishes clear evidence-based standards to ensure safe and accurate testing of children [8].

While to date, we are not aware of any published reported cases of COVID infection in staff or patients related to undergoing an in-lab sleep study, this is clearly a metric that will continue to be vital to track and report across the US and globally and make changes to policy to testing accordingly. During these challenging times, as much as safety of our patients and staff is utmost priority, it is also critical to focus attention ton the staff's emotional and physical wellbeing and sense of collegiality, as factors such as burn out, frequent virtual meetings, and online work without social interaction may continue for some time.

While we acknowledge that many of the challenges and solutions discussed above are relatively "US-centric", and that needs, knowledge, resource and service gaps vary widely across the globe, we hope that initiating an ongoing dialogue will provide guidance for the eventual development of global "best practices" for pediatric sleep labs by organizations such as the International Pediatric Sleep Association (IPSA). Given that it will take several years for the pandemic to completely subside and that we are likely to face future health and safety threats, a "new normal" about how we plan and operate our sleep centers will need to be created (Table 1). With ongoing opportunities to plan, design and build or remodel existing sleep laboratories, it will be critical to incorporate the lessons learned during the pandemic, so that in the future, the operations of pediatric sleep labs will continue to thrive and evolve.

Credit author statement

All listed authors were involved in the preparation and editing of and approved the attached revised manuscript.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.06.020.

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