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Assessment of Asthma Control in Children During the COVID-19 Pandemic: A Cross-Sectional Study at a Pediatric Hospital in Marrakech (Morroco)

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Abstract: Effective management of childhood asthma relies on regular and objective assessments to ensure optimal control. However, the implementation of containment measures during the COVID-19 pandemic has led to the postponement of pediatric consultations, posing significant challenges for children with asthma. This study aimed to evaluate asthma control among children attending pediatric consultations at the mother-child hospital in Marrakech during the lockdown period and to determine the influencing factors. This cross-sectional survey was conducted over one month, from April 6, 2020, to May 5, 2020. The target population consisted of asthmatic children (n = 66) receiving follow-up care at the University Hospital of Marrakech, along with their parents. Data were collected via telephone interviews. The Childhood Asthma Control Test (C-ACT) and Pediatric Medication Adherence Questionnaire-3 Weeks (PMAQ-3W) were used to assess asthma control and medication compliance respectively. Statistical analysis was performed using SPSS software, employing descriptive and correlational analysis. The children had a mean age of 7.5±2.5 years. The findings revealed a decrease in emergency room visits for children with asthma during the lockdown period compared to the previous year (19 vs. 46%, respectively). Moreover, 68% of children who visited the ER during the lockdown had uncontrolled asthma. According to C-ACT results, asthma was controlled in 71% of the children. Factors associated with good control included the absence of allergic rhinitis ($p<0.001$), absence of respiratory infection ($p<0.001$) and high adherence to medication ($p<0.001$). The confinement period had a positive impact on asthma according to 68% of parents. Conclusion maintaining optimal asthma control can be achieved through improved therapy adherence and avoidance of triggers. The conditions during the lockdown period met these requirements, indicating a beneficial effect on children with asthma. This implies the promotion of therapeutic education on medication compliance and avoidance of triggers, even outside confinement.

Keywords: Control, Asthma, Assessment, Confinement, Child

Introduction

Asthma is an inflammatory disorder of the airways characterized by episodic or persistent symptoms, including dyspnea, wheezing, bronchial hyperreactivity and cough (Lougheed *et al*., 2012). Its prevalence is significantly increasing, especially in developing countries (Morais-Almeida *et al*., 2020). In Morocco, the AIRMAG study indicated a prevalence of asthma in children of approximately 4.4% (Benkheder *et al*., 2009). In the city of Marrakech, there was an average annual growth rate of 10% in asthma consultations for children (Sadeq *et al*., 2015). Despite considerable advancements in understanding asthma, its management in children remains insufficient (Archibald *et al*., 2015). The most recommended approach to ensure proper management is the maintenance of an optimal level of control (Sawicki, 2018), which correlates with a better quality of life for children (Dean *et al*., 2009). The Global Asthma Initiative (GINA) has defined asthma control based on the noticeable intensity of its effects on patients. This includes daytime and nighttime symptoms, use of rescue therapy, activity limitation, lung function and the number of exacerbations (Venkatesan, 2023). However, maintaining control of childhood asthma is not always achieved. The ER'ASTHME study reported that asthma was only controlled in 27% of children (De Blic *et al*., 2007). In an African context, a large number of children had uncontrolled asthma, with rates of 30.9, 44.3 and 44.5% among children in Nigeria, South Africa and Uganda, respectively (Mphahlele *et al*., 2021). In Casablanca, Morocco, asthma control was only adequate in 7.6% of children (El Ftouh *et al*., 2009), but no such study has been conducted in Marrakech. Patients with uncontrolled asthma are at an increased risk of exacerbations, emergency room visits and hospitalization (Mjid *et al*., 2017).

Factors associated with loss of control should be investigated in these patients (De Blic *et al*., 2007), such as obesity, rhinitis, conjunctivitis, gastroesophageal reflux disease, food allergy, socioeconomic status and medication compliance (Venkatesan, 2023). Regular assessment of asthma control, at least quarterly, is highly recommended to achieve better management (Louis *et al*., 2010). However, since March 20th, 2020, when the health emergency was declared and lockdown measures were implemented due to the COVID-19 pandemic in Morocco leading to disruptions in access to healthcare, including consultations with asthmatic children have been postponed to optimize healthcare resources and ensure social distancing (Shaker *et al*., 2020). This has presented a significant challenge for children with asthma (Ferchichi *et al*., 2021), that was characterized by abrupt and remarkable transformations in the environment, lifestyle, medical practices and substance use (Oreskovic *et al*., 2020), as well as negative educational, psychological and financial impact (Ferchichi *et al*., 2021). These transformations can have an impact on asthma management, which is why we need to take these changes into account when assessing a loss of control situation (Underner *et al*., 2021).

This study is part of this framework, which had as its objectives, to evaluate asthma control in asthmatic children aged 4-11 years followed up in a pneumo-pediatric consultation in the city of Marrakech and to determine the factors influencing this control during the period of lockdown following the COVID-19 pandemic. This study will answer the following research questions: To what extent did asthmatic children aged 4-11 followed in a pneumo-pediatrics consultation at Marrakech University Hospital maintain adequate control of their asthma during the period of confinement due to the COVID-19 pandemic? What are the specific factors associated with asthma control in asthmatic children aged 4-11 followed up in a pneumo-pediatric consultation at Marrakech University Hospital during the containment period linked to the COVID-19 pandemic? And finally, how did the changes brought by confinement influence asthma control in asthmatic children aged 4-11 followed up in a pneumo-pediatric consultation at Marrakech University Hospital?

By answering all these questions, this study will provide important informations to guide asthma management strategies in children, particularly in the context of a health crisis. In addition, this study aims to fill a research gap by providing up-to-date data on asthma control in children in the city of Marrakech, given the lack of previous studies that specifically addressed this topic, which could inform public health policies and improve clinical practices in this region.

Materials and Methods

Study Design

This prospective cross-sectional survey was conducted during the lockdown period, spanning one month (from April 6, 2020, to May 5, 2020). Data collection was carried out through telephone interviews with parents of asthmatic children. The study was conducted at the pneumo-pediatric consultation unit of the Mother and Child Hospital (MCH) in the Mohamed VI University Hospital of Marrakech. This hospital provides care for asthmatic children up to the age of 15 from across the Marrakech region, offering services including hospitalization in pediatrics, pediatric emergencies and follow-up appointments at the pneumo-pediatric consultation unit. This consultation is conducted three times a week by professors specialized in pediatric pneumology, who were also informed about the present

study. For participant recruitment, the MCH information system was utilized to identify children with appointments during the data collection period and to identify the target population meeting the selection criteria. The necessary telephone numbers were also extracted from the same information system.

The Target Population

The study population was selected according to the following criteria.

Inclusion criteria:

- Children aged 4-11 years
- Children diagnosed with asthma at least 6 months prior to the start of the study, to ensure adequate time for assessing asthma control
- Children with appointments scheduled during the data collection period
- Children and parents willing to participate in the study

Exclusion criteria:

- Children with other respiratory problems
- The presence of cognitive or mental disorders that may influence the ability to understand questionnaire and C-ACT instructions

In this study, an exhaustive census methodology was employed to identify and include all children meeting the established selection criteria. This approach aimed to ensure maximum representativeness of the study population, avoiding any potential bias associated with participant selection.

Data Collection

In the present study, data collection involved the use of three tools.

A structured questionnaire comprising multiple sections addressing socio-demographic characteristics, asthma information, factors influencing asthma control and the impact of lockdown on children's asthma as reported by parents.

Patient medication adherence questionnaire over the last 3 days and the Preceding Weekend (PMAQ-3W): This validated questionnaire assessed medication adherence using five questions with three response options (Godard *et al*., 2005): "Total adherence if all doses were taken," "partial adherence if one dose was missed," and "non-adherence if more than one dose was missed."

Childhood Asthma Control Test (C-ACT): This validated tool for assessing asthma control in children aged 4-12 years over the last 4 weeks was utilized. It aimed to identify children with poorly controlled asthma, with specificity and sensitivity rates of 74 and 68% respectively. The test consists of seven questions, four for children and three for parents. A score lower than 20 indicates poor asthma control (Yavuz *et al*., 2012). The Arabic version of the C-ACT, previously validated in the United Arab Emirates (UAE) (AlTeneiji *et al*., 2018), was used after cultural adaptation. The investigator conducted data collection via telephone, completing the structured questionnaire and PMAQ-3W. The Arabic version of the C-ACT was electronically distributed to participants and the obtained scores were subsequently analyzed by the investigator.

Study Variables

In this study, the dependent variable was asthma control, with patients categorized into two groups: Controlled asthma and uncontrolled asthma. The independent variables included: Firstly, sociodemographic variables: Child's age, gender, number of household members, number of siblings, place of residence, type of housing, parents' education level and monthly income of the families. Secondly, asthma-related data. Thirdly, the impact of lockdown on children's asthma, as reported by the parents and lastly, factors influencing asthma control.

Ethics Statement

Prior to their participation in the study, informed consent was obtained from the parents of the participants. They were informed about the study's objectives, procedures and the confidentiality measures in place to safeguard their data. The study protocol was approved by the local ethical committee and immediate instructions and clarifications were provided as needed. Confidentiality and privacy protection were ensured through anonymous data collection methods.

Statistical Analysis

Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS), version 22. Continuous variables were described using the mean and standard deviation, while categorical variables were presented as absolute and relative frequencies. The chi-square test was employed to assess the association between qualitative variables and Spearman's test was used to examine the correlation between quantitative variables. Univariate analysis was utilized to describe and summarize the study findings. A

significance threshold of $p<0.05$ was applied to determine statistical significance for all tests conducted.

Results

Out of the 80 asthmatic children with scheduled appointments during the data collection period, a total of 66 children (82%) were included in the study. This inclusion rate accounts for non-response from 10 participants and refusal to participate by four parents.

Socio-Demographic Characteristics

The age distribution of the included children showed a predominant presence of four to 6-year-olds (41%). The mean age was 7.5 years, with a standard deviation of ±2.5. More than half of the children were male (58%). The majority of participants lived in single-family homes (53%), with an average household size of 4.5 people. Most fathers had a primary school education, while most mothers were illiterate. The monthly average family income did not exceed 2,000 MAD. Table 1 presents the key characteristics of the asthmatic children.

Comorbid Conditions and Asthma-Related Triggers

Regarding comorbidities, conjunctivitis was reported in 9% of cases, while rhinitis was observed in 13.5%. Additionally, 10.5% of the children experienced respiratory infections. Environmental factors were also considered, with 4.5% of the children having pets and 10.5% being exposed to tobacco smoke (Table 1).

Children's Level of Asthma Control During Lockdown

The majority of cases demonstrated well-controlled asthma (71%), indicated by a C-ACT score greater than 20. Additionally, 68% of parents agreed that the period of confinement had a positive impact on their children's asthma control (Table 1).

Table 1: General characteristics of asthmatic children followed in a pneumo-pediatric consultation in the city of Marrakech, Morroco (n = 66)

Variable	n	%
Sociodemographic characteristics		
Age (years)		
[4, 6]	27	41
[7, 9]	18	27
[10,11]	21	32
Mean (SD)	7,5	(2,5)
Gender		
Male	38	58
Female	28	42
Family income		
I<2000 MAD	43	65
2000 MAD <I <4000 MAD	11	17
4000 MAD <I <6000 MAD	10	15
I>6000 MAD	2	3
Father's level of education		
Illiterate	17	26
Primary	29	44
Secondary	16	24
University	4	6
Mother's level of education		
Illiterate	28	42
Primary	21	32
Secondary	15	23
University	2	3
Number of siblings		
0-2	48	73
3 or more	18	27
Age of asthma		
< 2 years	15	22,7
>2 years		
Clinical characteristics	51	77,3
Therapeutic compliance		
Observant	38	57,6
Moderately observant	6	9,1
Non-observant	22	33,3
Allergic rhinitis		
Yes	9	14
No	57	86
Passive smoking		
Yes	7	11
No	59	89
Respiratory infection		
Yes	7	11
No	59	89
Conjunctivitis		
Yes	6	9
No	60	91
Emergency room visits per month during containment		
None	53	80
1 time	8	12
2 or more times	5	8
Degree of impact of confinement on the child's asthma according to parents		
Positively	45	68
Negatively	7	11
No impact	14	21

SD: Standard Deviation, MAD: Official monetary currency of Morocco

Table 2: Controlled asthma in patients (N = 66)

Variable	Controlled asthma (n = 47)	Uncontrolled asthma (n = 19)	Total	P
Age (years)				
[4, 6]	20	7	27	,803
[7, 9]	12	6	18	
[10,11]	15	6	21	
Gender				,560
Male	26	12	38	
Female	21	7	28	
Family income				,644
I<2000 MAD	30	13	43	
2000 MAD <I <4000 MAD	8	3	11	
4000 MAD<I <6000 MAD	7	3	10	
I>6000 MAD	2	0	2	
Father's level of education				,360
Illiterate	11	6	17	
Primary	19	10	29	
Secondary	13	3	16	
University	4	0	4	
Mother's level of education				,331
Illiterate	18	10	28	
Primary	14	7	21	
Secondary	13	2	15	
University	2	0	2	
Number of siblings				,243
0-2	34	14	48	
3 or more	13	5	18	
Age of asthma				,275
< 2 years	9	6	15	
>2 years	38	13	51	
Therapeutic compliance				0,000
Observant	38	0	38	
Moderately observant	4	2	6	
Non-observant	5	17	22	
Allergic rhinitis				0,000
Yes	0	9	9	
No	47	10	57	
Passive smoking				,385
Yes	4	3	7	
No	43	16	59	
Respiratory infection				0,000
Yes	1	6	7	
No	46	13	59	
Emergency room visits per month during containment				0,000
None	47	6	53	
1 time	0	8	8	
2 or more times	0	5	5	

p<0.05 is considered significant

Emergency Room Visits by Asthmatic Children During Confinement

Results showed a decrease in emergency room visits during the confinement period compared to the previous year (19 vs. 46%, respectively). Additionally, a significant association was found between asthma control and emergency department visits. None of the children with controlled asthma required emergency department visits, while 68% of children with uncontrolled asthma sought care at the emergency department (p<0.001).

Factors Associated with Asthma Control in Children

The bivariate analysis identified several factors associated with good asthma control, including the absence of allergic rhinitis (p<0.001), the absence of respiratory infections (p<0.001) and high medication

compliance ($p<0.001$) (Table 2).

Discussion

The objectives of this study were to assess the level of asthma control and to determine associated factors in asthmatic children aged 4-11 during the period of containment following the COVID-19 pandemic. The present study demonstrated the improvement in asthma control among children during the period of lockdown. This finding was supported in several ways: Firstly, the assessment of asthma control using the C-ACT during lockdown; secondly, the comparison of emergency room visits before and during lockdown, as reported by parents; and finally, feedback from parents regarding the impact of lockdown on their children's asthma.

Our results align with previous studies that have shown a predominant level of well-controlled asthma in children during lockdown. In fact, a global survey involving asthmatic children from five continents found that only 10% of cases had uncontrolled asthma (Papadopoulos *et al*., 2022). Another study conducted on 123 asthmatic children demonstrated that 53.7% of them experienced improved control compared to the same period in the previous year (Sancakli *et al*., 2022). In Africa, a survey conducted in Ethiopia on 105 children, which coincided with the lockdown period, showed that 68.5% of the cases had well-controlled asthma (Aschalew *et al*., 2022). In contrast, studies conducted before the lockdown period indicated a higher prevalence of uncontrolled asthma among asthmatic children, with rates of 66% in France (De Blic *et al*., 2007) and 53% in the United States of America (Gandhi *et al*., 2013). Given the unavailability of data on asthma control in children prior to the lockdown in the context of our study for conducting a comparison between the two periods (before and during the lockdown), we had to rely on parental feedback regarding their children's asthma during both periods. Parents judged that the asthma control in their children significantly improved during this period compared to the same period of the previous year. This observation was confirmed by both the families contacted for routine asthma examinations (Chavasse *et al*., 2020) and another survey conducted with 595 parents, where more than half of them perceived a significant improvement in asthma control in their children during the lockdown (Pogge *et al*., 2020).

When comparing emergency room visits before and during the lockdown, a significant reduction in emergency visits was observed during the latter period. In fact, the decrease in emergency room visits reached up to 90% (Chavasse *et al*., 2020) with fewer exacerbation cases reported (Ferchichi *et al*., 2021). This contrasts with the high frequency of emergency visits by asthmatic children before the lockdown (Blanc *et al*., 2002; Liard *et al*., 2001). This decrease can be attributed to the maintenance of good asthma control during lockdown (Nagakumar *et al*., 2021). Respiratory infections and allergic rhinitis were less prevalent among asthmatic children during lockdown, primarily due to reduced exposure to irritants, allergens and viruses while staying at home for an extended period (Creese *et al*., 2020). Since respiratory infections exacerbate asthma symptoms (Zheng *et al*., 2018; Mahdi *et al*., 2015) and the onset of allergic rhinitis negatively affects asthma control (Bechikh *et al*., 2018), the decrease of these factors during lockdown contributed to better asthma control in our study population. The improvement in asthma control during lockdown may also be attributed to the decrease in air pollution resulting from reduced air and road traffic (Khomsi *et al*., 2020), as well as reduced industrial activity (Taquechel *et al*., 2020).

Although reduced physical activity and increased exposure to household allergens and disinfectants during lockdown were potential disadvantages (Castro-Rodriguez and Forno, 2020; Chavasse *et al.,* 2020), no negative effect on asthma control was observed in the children in our study. Improved medication compliance and its positive impact on asthma control during lockdown have been reported in prior studies conducted under similar circumstances (Creese *et al*., 2020; Kaye *et al*., 2020). Despite the difficulty in accessing healthcare services during the confinement, it did not have a negative effect on therapeutic adherence (Sancakli *et al*., 2022). However, prior to confinement, therapeutic compliance was often inadequate (Carvelli and Battisti, 2010). This had a negative impact on asthma control, as confirmed by several studies (Burgess *et al*., 2011; Al-Muhsen *et al*., 2015; Xiang *et al*., 2016).

Indeed, healthcare practitioners can be encouraged to provide additional support to children and their parents to maintain better medication compliance outside periods of confinement. This can involve ongoing education, regular reminders and strategies for integrating medication intake into daily routines.

An example of such strategies is the system set up in a pneumology department in Belgium, which aims to educate patients and their families while facilitating self-assessment of asthma control and rapid prescription of adaptive treatment plans for various asthmatic situations (Carvelli and Battisti, 2010). Similarly, Electronic Monitoring Devices (EMDs) remind patients to take their

medication, as a strategy to motivate patients to maintain better medication adherence (Burgess *et al*., 2011).

The exact reasons for this improved level of adherence have not been conclusively determined (Underner *et al*., 2021), but they may be linked to parents' concerns that respiratory symptoms could be associated or confused with COVID-19 (Kaye *et al*., 2020). Additionally, parental involvement, which plays a key role in therapeutic adherence (Morais-Almeida *et al*., 2020), was enhanced due to parents' availability to their children throughout the lockdown period, resulting from school closures and the adoption of remote work.

The data from this study confirms that the preventive measures implemented following the COVID-19 pandemic has led to a reduction in children's exposure to asthma triggers, as well as a decrease in outdoor air pollution. Additionally, parents' heightened concern for their children's health, coupled with their increased availability during confinement, contributed to improved treatment compliance. These changes had a positive impact on children's asthma control, resulting in fewer asthma-related emergency room visits.

The results of our study provide valuable insight into the beneficial effects of confinement on asthma management in children, highlighting the importance of considering the interactions between medication adherence, indoor and outdoor environments and access to care in asthma management. This underscores the notion that changes in routine or context can influence the behavior of asthmatic children and their parents in managing the disease.

Furthermore, these results emphasize the importance of integrating environmental and behavioral aspects into public health research to better understand the determinants of pediatric respiratory health in evolving contexts.

However, this study had certain limitations. Firstly, the small number of participants prevented the exploration of data for all children with appointments during the data collection period. Secondly, the non-utilization of patients' medical records and finally, the absence of local data on asthma control levels in children before the lockdown, limited the possibility of making a more contextualized and objective comparison.

Conclusion

In conclusion, the majority of asthmatic children followed up at Marrakech University Hospital had their asthma under control during the period of confinement. Several factors were identified in this study, including improved compliance with medication, avoidance of triggers (especially respiratory infections), fewer cases of allergic rhinitis and reduced outdoor air pollution. These factors were attributable to the preventive measures adopted during containment following the COVID-19 pandemic. Based on the conclusions drawn from this study, a series of corrective actions need to be implemented even after the period of confinement to enhance asthma control in asthmatic children and reduce their visits to emergency departments. This includes promoting better medication compliance and raising awareness among children and their parents about avoiding triggers and adequately treating comorbidities. Furthermore, our results underscore the importance of public health policies aimed at reducing air pollution, which could have beneficial effects on the respiratory health of asthmatic children.

This study lays the foundation for future research endeavors. Subsequent studies could aim to evaluate asthma control and its influencing factors in children by focusing on a larger sample size. Involving healthcare professionals in these studies would enable the exploration of additional relevant variables (medical records, allergy tests, etc.) and the exploration of more diversified contexts, in order to confirm and generalize the conclusions of the present study.

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Author’s Contributions

Maryem Labyad: Initial study designed, general coordination of the project, planned of the research methodology, development of data collection tools, data collection, analysis and interpretation of data, written of the manuscript and revision of the manuscript.

Karima El Fakiri: Analysis and interpretation of data, written of the manuscript and revision.

Abdelmounaim Baslam: Submission of the manuscript to the journal and revision of the manuscript.

Widad Lahmini: Planned of the research methodology, development of the data collection tools

and proofreading.

Ghizlaine Draiss, Nadia Ouzennou and Mohamed Bouskraoui: Initial study designed, planned of the research methodology, development of data collection tools, revision and supervision.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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