UNIVERSITY OF
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Intellihaling

ECE1778 – Creative Applications for Mobile Devices

Project Final Report

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Introduction

250 Canadians died from Asthma and 70, 000 ER visits were due to Asthma in 2015. Asthmatic symptoms are also the major reason for school absenteeism. (www.asthma.ca)

Asthmatics symptoms include include shortness of breath, chest tightening, coughing, and wheezing. Patients with Asthma can be prescribed two types of inhalers for treatment. One for immediate short term relief (Ventolin) which is taken by the patient when they feel shortness of breath and secondly for longer term relief. Although it is important for patients to take the Ventolin when they feel the onset of symptoms, once Ventolin inhaler's are prescribed patients are left to self diagnose when they feel the onset of symptoms in order to take the life saving medication which they do independently.

Asthma is often misdiagnosed in school aged children(Yang, Simons, Faty, Subbararo, To and Dell, 2017). Patients may not be able to accurately assess if they need the medication and if their shortness of breath is actually due to Asthma. According to Cole, Seale and Griffiths (2013) short – term relief inhalers are overused and often taken when it is not necessary by young adults. This results in poor asthma control in patients resulting in increased risk of death and financial strain on the healthcare system. According to Durrani (2014) assessing severity of Asthma and monitoring control is imperative for optimal management. The Intellihaling app is designed to address this problem by allowing school aged patients to accurately diagnose their condition before taking the Ventolin inhaler using the Peakflow meter. Peakflow meter checks for speed of airflow to the lungs. The spirometer will also be used to assess the quality of breathing and lung capacity to give a more accurate assessment of lung function.

Parents and children often do not realise that they can manage the Asthma symptoms without needing to go to the hospital. By providing step by step instructions, while monitoring the severity of the condition, the app is able to guide parents and children in treating the patients without sending them to the hospital. In the case that the symptoms are not manageable the app facilitates the connection with the emergency services.

Currently parents are not able to monitor children's inhaler usage or condition when they are not with the children. This app provides real time notifications to the parent on the child's condition and inhaler usage giving parents more control of their child's health.

When a patient is experiencing Asthma symptoms, if the patient does not have an inhaler they need to obtain a prescription from the family physician. If a family physician's clinic is not open the patient would have to go to the hospital emergency department for treatment. This puts additional pressure on the patient and the health care system which could have been avoided if the patient had been reminded to reorder the inhalers.

This App is designed to prevent emergency room visits by Asthmatic school aged children who need to take the Ventolin inhaler and who can take the inhaler independently.

Statement of Functionality

The Intellihaling app is designed to assess if a child is experiencing Asthma symptoms. It provides a guide to manage Asthmatic symptoms. If the patient's condition continues to deteriorate the app connects to emergency services. The app allows for supply of inhalers to be maintained and finally patient data is available as a chart to enable Asthma management planning. This app links the parent and child (patient's) phone.

The app has the following functions:

- **Identifies if shortness of breath is due to Asthma**

  Child

  When the patient (Child) is feeling shortness of breath, (before taking medication from the inhaler), an assessment will be done to determine if the symptoms are actually due to Asthma. The assessment levels are based on the guidelines provided for Asthmatic children (Appendix B) The app will check patients heart rate using the camera, speed of air flow using a Peak-flow meter, and quality of airflow and lung capacity using a Spirometer, along with age, height and weight. The patient will be asked to blow into the peakflow meter and spirometer and to record the readings into the app. If the symptoms are not due to Asthma the patients will be instructed to continue with their daily activity.

  Parent

  The parent will be sent a notification that the child is experiencing shortness of breath. If the symptoms are not due to Asthma the notification will inform the parents that the child does not need the inhaler and can continue their daily activities.

- **Managing Asthmatic conditions**

    Child

    If the Peakflow meter and Spirometer data suggests that the patient has Asthmatic symptoms step by step instructions will be provided to the patient to allow them to manage the symptoms and receive timely treatment without needing to go to the hospital. These instructions would include:

    1) Give 2 puffs of the Ventolin inhaler
    2) Wait one minute
    3) Blow into the peakflow and spirometer 3 times
    4) Record the highest of the three reading which will be displayed on the meter. This reading will be displayed on the peakflow/ spirometer device.

    If peakflow meter/ Spirometer results are in the yellow or red severity zone (Appendix B) the patient will be asked to continue with steps 1-4 until either the results reveal that the patient's breathing is normal and no longer needs an inhaler or until the patient has repeated steps 1-4, five times (10 puffs) and continued to report readings in severe red range (**Appendix B).**

    Parent

    The parent is sent a real-time notification on the severity of the patient symptoms based on the results from the Peakflow meter and spirometer readings.

- **Emergency services dispatched**

  Child

  After the patient has inhaled 10 puffs of the inhaler and has continuously displayed severe Asthmatic symptoms with no improvements(Red zone) the emergency services will be contacted and dispatched. The emergency services will continue to communicate with the patient until the paramedics reach the patient.

  Parent

  The parent will be notified that, "the child's symptoms continue to be severe after 10 puffs of the inhaler and that the emergency services have been dispatched". The parent, child and emergency services will all be connected on the call until the paramedics arrive to the patient.

- **Reminders for adequate supply of working inhalers**

  The Ventolin inhaler allows for 200 puffs before the first use. Patients take 2 puffs at one time. When 10 puffs of the inhaler are remaining a notification will be sent to the patient to order replacement inhalers.

  When 5 days are left before expiry, the app will send a reminder to the child and parent to order a new inhaler. The pharmacist and the physicians clinic will also be notified that the patient needs a new inhaler.

- **Charts - Peakflow/ Spirometer data record**

  Data collected is charted and used by parents to work with health care practitioners on preventative strategies.

  The parent would set up the child's profile by adding the child's height, weight

and demographic information at the time of registration with the app. The Height and weight together with the readings from the peakflow meter and the spirometer will be used to determine a patient's Asthma severity level.

The patient's baseline data (heart rate, peakflow and spirometer readings) will be available in a chart. The patient's inhaler usage together with the peak-flow and spirometer readings will also be available over time. The information will also be kept in a database. This will allow for preventative planning between the parent and the healthcare provider.

Screenshots from App

Main page: children & parent version
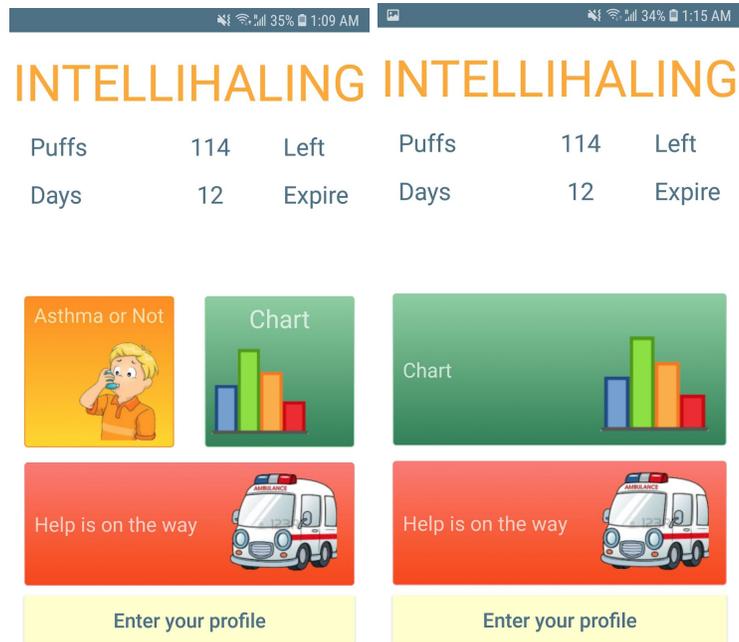
Functionalities:

1. **Asthma symptom assessment process**
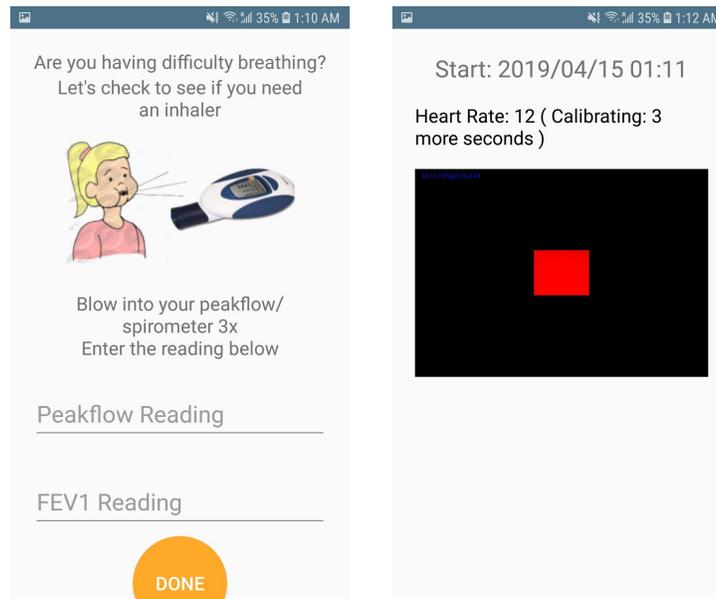
Figure. Lung capacity input & estimation/ Heart rate detection

Shortfall:

In this app, we didn't achieve automatic data transfer via bluetooth. This supplementary function is important as patients suffering from severe asthma symptoms, may not want to spend time or effort typing in data manually. Automatic data transfer function gives patients a friendlier and more reliable user experience.

2. **Asthma symptom management process**
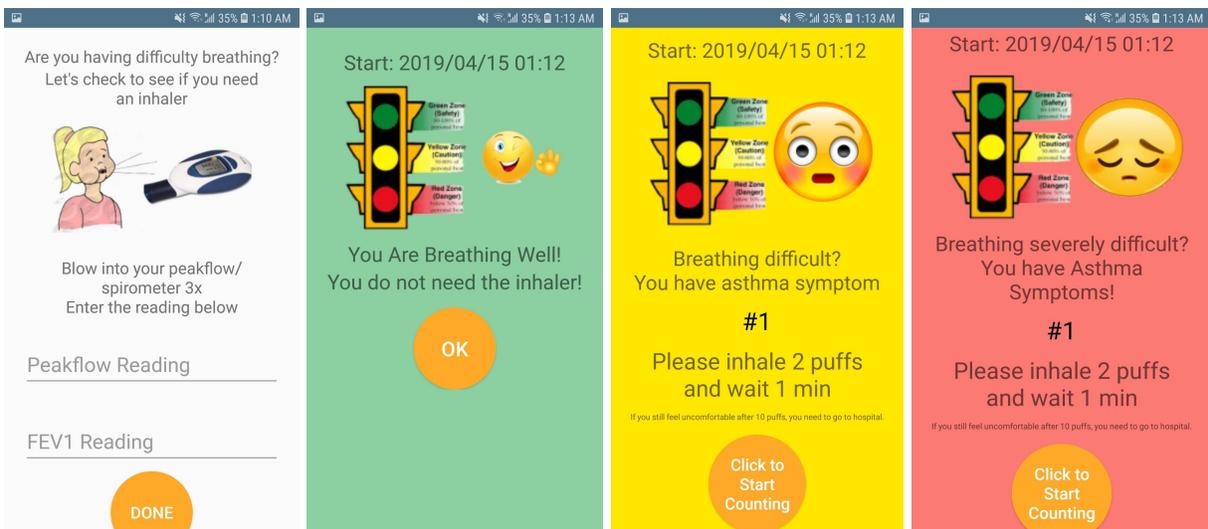
Figure. Lung capacity input & estimation/ Assessment result display

3. Emergency service calling
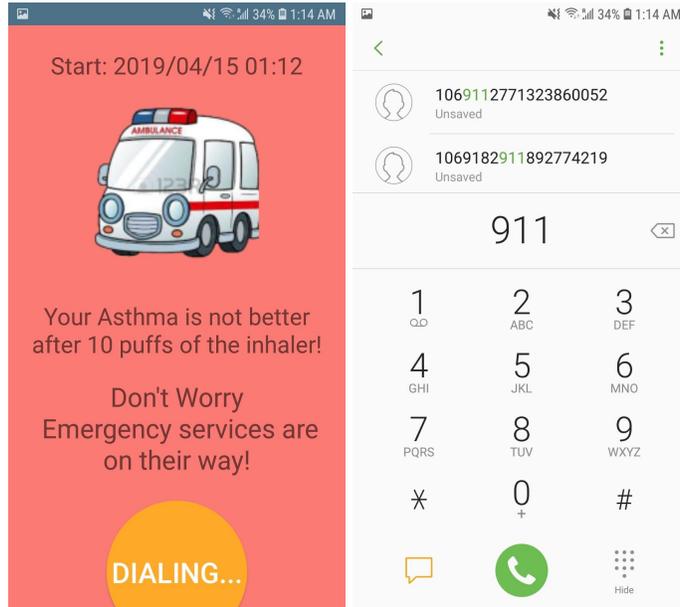

4. Reminder inhaler
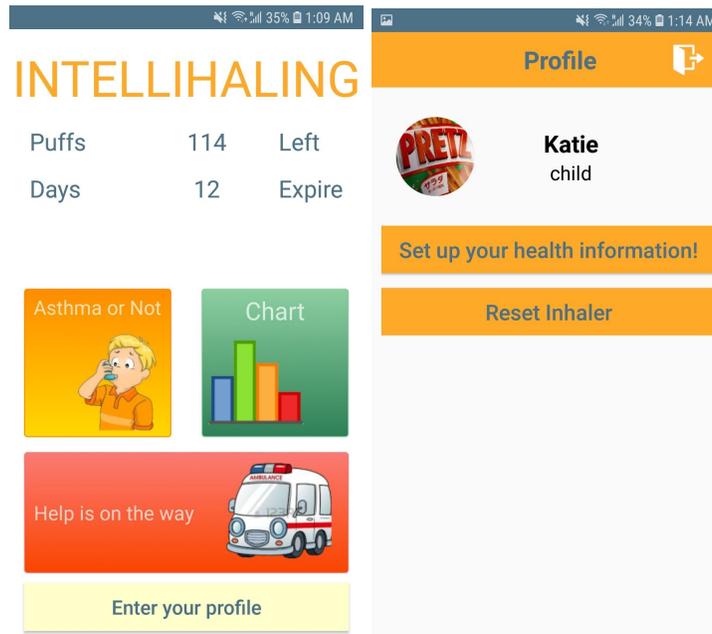
Figure. Medicine margin and shelf life display/ Inhaler default setting reset

5. Chart
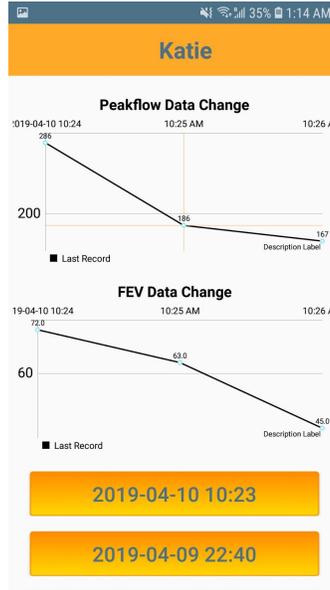
Shortfall:

Currently, users can only see their total records in chronological order. In our original design, users could look up their medical records daily, monthly and yearly. This is important because patients, parents and doctor's an accurate history of the patient's medical condition.

6. Login & Registration

Overall Design (Yvonne and Mike)
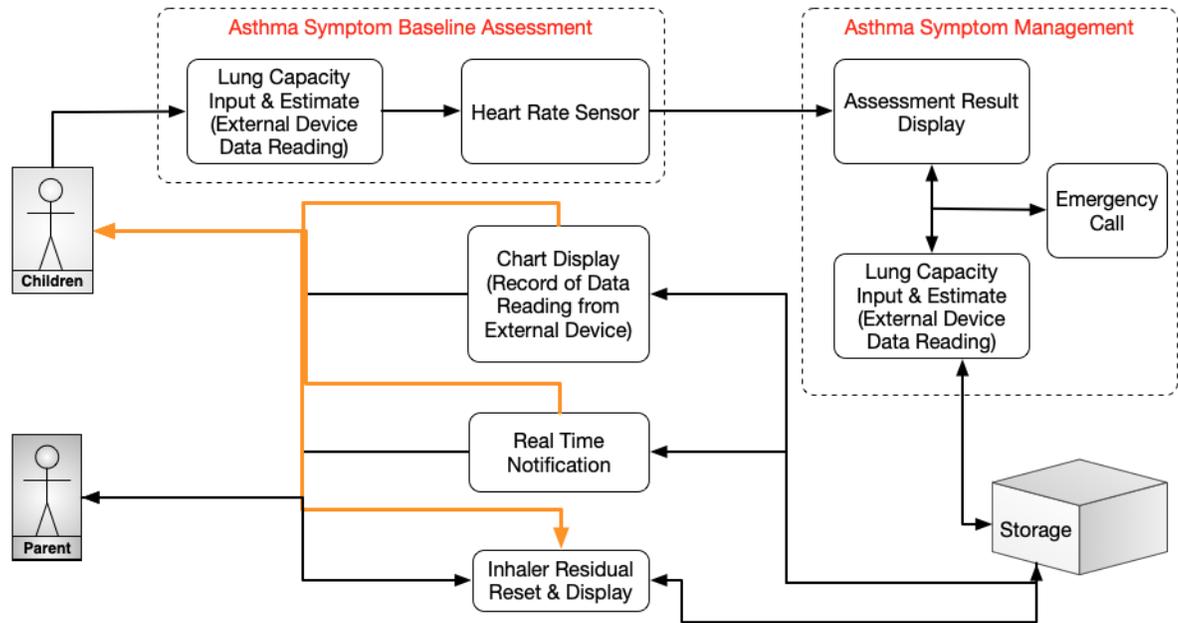
Software Block Diagram

The software contains four parts:

1. Asthma symptom baseline assessment and management

    Children's account only. When the user needs to assess and manage asthma symptoms, they complete baseline assessment first. Baseline assessment includes two steps:

     a) external device (peakflow / spirometer FEV1) data reading input by user manually based on the guide displayed on the screen.

    b). heart rate monitor based on the skin color change which is captured by the camera when a user places their finger on the phone.

    Symptom management is implemented with two activities, one includes display and estimation steps and the other one includes calling emergency service. Based on the external device data reading (Peakflow and FEV1) and heart rate

from baseline assessment , the results accurately determine if the user actually does have Asthma symptoms. Corresponding severity levels are displayed on the screen. If the lung capacity data reading (peakflow/ FEV1 reading) is in the range of average peakflow and mild asthma (**Appendix A**), the user has no risk of having asthma symptoms and the interface will show this result. If the user is confirmed to have severe asthma symptoms, the instructions will be displayed on the screen on how to use the inhaler/ medicine and then the user will be required to test lung capacity estimation again.

The process of estimation and instructions/ result display will continue repeating until the FEV1 and Peakflow meter reading inputted by the user is no longer exhibiting a severe range of asthma or the medicine taken from the inhaler is over ten puffs. When a patient has taken 10 puffs and the condition continues to be identified as severe, the system will redirect to call emergency services. Meanwhile, the data read from the external device and the margin of medicine taken from inhaler will be sent to the database (firebase).

2. Chart display

This part is allowed for both children and parent accounts. It will read documents from firebase based on the UID of the patient and the chart will display the change of data in each document. Each document contain the data record from external device inputted by user during one time assessment and management. Documents are sorted by chronological order.

3. Real time notification monitor and transmission

This part is the process of sending notification about the usage of asthma symptom assessment and management function from children to parent and the margin of medicine from inhaler to both accounts. To achieve this, the software

will monitor any change to specific documents through the function provided by firebase. These documents will change their content when specific buttons in assessment and management processes are triggered or when the margin of medicine is lower than the specific value. If change is detected, the software will send notification with corresponding alert content to itself. By allowing the permission of this software, the notification can be shown on lock screen, notification center, banners and badges, as long as it is running in the background.

4. Inhaler residual reset and display

This part is allowed for both children and parent accounts. Both children and parents can see the medicine margin and shelf life information on the main page of the software. User can reset the number to default settings when the inhaler has almost run out. The default setting for capacity of medicine in inhaler is 200 puffs and the shelf life is 20 days.

Reflection

For Specialist:

- Learnt how to make an app using Marvel. I would like to have had a better understanding of how the coding works.
- I learnt how to develop an app with features that would be applicable for different audiences.
- Asthma guidelines.
- Heart rate can be assessed using camera.
- I would like to know what the next steps would be to bring the app to the market and to build a small start up business with apps.

For programmers:

- Practical Android developing training.
- Learnt how to handle asynchronous issues when calling firebase methods.
- Learnt how to use fragments to decrease number of unnecessary activities.
- Effective UI design with minimizing the workload of repeating changes.
- Normalized database design.

Contribution

- Saddaf

  Idea development, research topic area, usability testing: survey physicians, patients, provided parent perspective, interface design

- Yuan Ma

  Inhaler information resetter, emergency service function, charts, database design, part of UI, backend-frontend data transfer.

- Jingyi Li

  Overall UI design, database design, registration function, baseline assessment process, heartbeat rate detection function, asthma management process, diagnosis algorithm implementation, parent and child link function.

Describe how what was achieved can influence your research field, or the field of application.

Currently there are many problems with the treatment offered to Asthmatic children. This app would allow the diagnosis of Asthma to be done more accurately by the patient themselves before inhaling the Ventolin medication. This app would prevent over usage of medication when symptoms do not actually exist. It would also allow for the patient and the parent to be able to manage the symptoms and subsequently prevent emergency room visits by following assessment and treatment guidelines. Currently as a parent I am not able to accurately assess how much dosage my daughter has left in her inhaler. This app provides a feature that not only notifies patients when the inhaler prescription needs to be refilled due to dosage remaining but it also advises when the inhaler is due to expire. This would also prevent unnecessary emergency room visits due to patients not having inhalers when the family physician clinics are closed. Finally the biggest advantage of this app is that parents are able to monitor the child's usage of the inhaler and their condition. This can help the parent work through a preventative strategy with the health care providers. By linking these features to the electronic medical records and by having bluetooth capabilities on the peakflow/ spirometer we can have a more effective mechanism for achieving these goals.

We hope to be able to have notifications sent to parents and the electronic medical records in real time. These features would make a significant breakthrough addressing the current gaps in the field of pediatric Asthma.

Future Work

- Inhaler is connected to the spirometer and peakflow meter using bluetooth to allow for the app to automatically transfer the readings to the app
- The app can sense when the patient is experiencing shortness of breath and advises patient to begin the assessment.
- Connect the app to the patient's Electronic medical record in real time
- Speech assessment: When patient is feeling shortness of breath, they read the sentence on screen and the app will give diagnosis based on the loudness, clarity, speed of speech and time of the audio.
- GPS location can be retrieved when connection to emergency services

Statement

Saddaf Syed, Yuan Ma, Jingyi Li are ok with posting each item listed below.

      i. Video of final presentation

      ii. Report

      iii. Source code

Word count: 2499

Appendix A - Assessment of Asthma using Peakflow and Spirometer readings

Height in inches	Average peak flow	Yellow Zone 50-80% of average peak flow	Red Zone less than 50% of average peak flow
43	147	74 - 118	< 74
44	160	80 - 128	< 80
45	173	87 - 139	< 87
46	187	94 - 150	< 94
47	200	100 - 160	< 100
48	214	107 - 171	< 107
49	227	114 - 182	< 114
50	240	120 - 192	< 120
51	254	127 - 203	< 127
52	267	134 - 214	< 134
53	280	140 - 224	< 140
54	293	147 - 234	< 147
55	307	154 - 246	< 154
56	320	160 - 256	< 160
57	334	167 - 267	< 167
58	347	174 - 278	< 174
59	360	180 - 288	< 180
60	373	187 - 298	< 187

Table 2. Classifying asthma severity

	Mild Asthma	Moderate Asthma	Severe Asthma
FEV_1	>80%	60%-80%	<60%
FEV_1/FVC	*Adults:* Normal *Children:* >80%	*Adults:* Reduced 5% *Children:* 75%-80%	*Adults:* Reduced >5% *Children:* <75%

file:///C:/Users/syedsadd/AppData/Local/Microsoft/Windows/INetCache/Content.Outlook/Y0A34M2W/asthma%20kids%20(00000002).pdf

Appendix B - Assessment of Asthma guide

Mild	Moderate	Severe
• No Shortness of Breath (SOB) at rest. •Mild SOB with walking. •Can talk normally. Speaks in sentences. •Can lay down flat. Wheezes not heard or mild. •(Green Zone: PeakFlow Rate 80-100% of normal rate) ● Spirometer reading FEV1 children. Greater than 80%.	•SOB at rest. •Speaks in phrases. •Wants to sit (can't lay down flat). •Wheezing can be heard. Retractions are present (ribs pull in with each breath). •((Yellow Zone: PeakFlow Rate 50-80% of normal rate) ● Spirometer reading FEV1. children less than 75% - 80%.	•Severe SOB at rest. •Speaks in single words. •Struggling to breathe. Wheezing may be loud. •Rarely, wheezing is absent due to poor air movement. Retractions may be severe. •(Red Zone: PeakFlow Rate less than 50% of normal rate) ● Spirometer reading FEV1 children. Greater than 80%.

https://www.seattlechildrens.org/conditions/a-z/asthma-attack/https://www.seattlechildrens.org/conditions/a-z/asthma-attack/

References

1. Aaron, S. D., Boulet, L. P., Reddel, H. K., & Gershon, A. S. (2018). Underdiagnosis and Overdiagnosis of Asthma. *American Journal of Respiratory and Critical Care Medicine,198*(8). doi:https://doi.org/10.1164/rccm.201804-0682CI PubMed: 29756989

2. Cole, S., Seale, C., & Griffiths, C. (2013). 'The blue one takes a battering' why do young adults with asthma overuse bronchodilator inhalers? A qualitative study: Table 1. *BMJ Open,3*(2). doi:10.1136/bmjopen-2012-002247

3. Durrani, S. (2014). Management of Asthma in School-Aged Children and Adolescents. *Pediatric Annals,43*(8). doi:10.3928/00904481-20140723-08
https://www.ncbi.nlm.nih.gov/pubmed/25102488

4. Asthma Facts and Statistics. (2019, February 02). Retrieved April 15, 2019, from
https://asthma.ca/wp-content/uploads/2019/02/Asthma-101.pdf

5. The Lung Association of Ontario (2014, September). Paediatric Emergency Department Asthma Clinical Pathway. Retrieved from
file:///C:/Users/syedsadd/AppData/Local/Microsoft/Windows/INetCache/Content.Outlook/Y0A34M2W/pedacp-information-package-september-2014 (1) (00000003).pdf