COMPARISON OF TWO RESPIRATORY SCORES IN CHILDREN WITH ACUTE BRONCHIOLITIS

DR TAN WEE NEE

MBBS (AIMST)

DEPARTMENT OF PEDIATRICs

FACULTY OF MEDICINE

UNIVERSITY OF MALAYA

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Contents

Abstract

Background : Respiratory scores are an objective method of detecting severity of disease and response to treatment. However, choosing the most accurate system can be confusing with the availability of many different scores of varying complexities.

Objectives: The objectives of this study were to a) compare 2 respiratory scores i.e. Kristjansson Respiratory Score (KRS) and Children's Hospital of Wisconsin Respiratory Scores (CHWRS), at predicting admission, b) correlate oxygen saturation at with length of stay (LOS), need for admission andnon-invasive ventilator, c) correlate change in respiratory score within 24 hours admission and LOS, d) determine the inter-rater reliability of the 2 scores, e) determine the association between aetiology and length of stay and e) identify components of the respiratory score which correlated with admission, in children admitted with bronchiolitis.

Design: This is a single center, cross-sectional study at Pediatric Trauma Unit, University Malaya Medical Centre, from March 2017 to August 2017.

Sample Population: Children aged 1 till 18 months old presenting with acute bronchiolitis were included. Patients with: chronic respiratory disease, congenital heart disease, more than 2 episodes of wheezing, diagnosis of asthma, symptoms more than 14 days and parents who refused consent were excluded.

Methods: Each patient was assessed by 2 doctors using the 2 scoring systems(KRS and CHWRS) in the emergency department and within 24 hours after admission . Admission was decided by the managing doctor. , Demographic date, length of stay, nasopharyngeal cultures and virology, treatment received during admission and clinical progress were collected.

Results: One hundred and twenty-nine children met the inclusion criteria but only 122 patients were recruited. Median (IQR) age of patients was 9 (6,12) months old and majority were discharged (69.7%). The area under receiver operating characteristic curve (aROC) for predicting admission was 0.832 for Children's Hospital of Winconsin Respiratory Score and 0.760 for Kristjansson Respiratory Score.

Low saturation (Spo2 $\leq$ 95%) was associated with need for admission (p=0.008) and for non-invasive ventilation (p= 0.027).

The inter-rater reliability between the first and second assessors for CHWRS (Intraclass Classification [ICC] 0.918) was higher than for KRS (ICC: 0.829). The highest inter-rater reliability for CHWRS were chest x-ray (ICC 0.918) and heart rate (ICC 0.892); whereas for the KRS, general condition (ICC 0.749) and respiratory rate (ICC0.742) were the highest.

There was no association between length of stay and change in respiratory score from admission to 24 hrs after admission (CHWRS r= 0.137, p 0.418; KRS r= 0.157, p= 0.352). Co-infection (bacterial and virus) was associated with a longer hospital stay (p=0.032). Breath sounds and surgical status in the CHWRS and breath sounds and skin colour in the KRS were poor at predicting admission.

Conclusion

CHWRS had a better discriminative power in predicting admission and higher inter-rater reliability compared to KRS. Low saturation was significantly associated with the need for admission and non-invasive ventilation. Co-infection (bacterial and virus) was associated with a longer hospital stay. Breath sounds and skin colour were poor at predicting outcome.

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ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Tan Wee Nee (I.C/Passport No: 840204-02-5456)

Matric No: MGH 130012

Name of Degree: Postgraduate Master of Paediatrics

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Jabatan Pediatrik
Pusat Perubatan Universiti Malaya

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PROFESOR MADYA DR. ANNA MARIE NATHAN
No. Pendaftaran Penuh MPM 36147
Pakar Perunding
Jabatan Pediatrik PPUM

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Abbreviations

aROC	Area Under Receiving Operator Curve
BIPAP	Bilevel Positive Airway Pressure
CHWRS	Children's Hospital of Wisconsin Respiratory Scores
CPAP	Continuous Positive Airway Pressure
CXR	Chest X-Ray
Hrs	Hours
HKB	Hospital Kota Bahru
HUSM	Hospital Universiti Sains Malaysia
ICC	Intraclass Correlation
KRS	Kristjansson Respiratory Score
NPS	Nasopharyngeal Secretion
PICU	Pediatric Intensive Care Unit
RDAI	Respiratory Distress Assessment Instrument
SPO2	Peripheral Capillary Oxygen Saturation
SPSS	Statistical Package for the Social Sciences
UMMC	University Malaya Medical Centre
WHO	World Health Organization

Chapter 1: Introduction

Acute bronchiolitis is a clinical syndrome characterized by wheezing and dyspnea caused by viral infection of lower respiratory tract, commonly seen in children less than 18 months old. Other common presentations are cough, rhinorrhea, fever, reduced appetite, reduced active, cyanosis and apnea. The viral infection involves the lower respiratory tract, causing acute inflammation, oedema, necrosis of epithelial of small airways, subsequently mucus secretion, hence resulting in airway obstruction and hyperinflation of lung. (American Academy of Pediatrics Subcommittee on & Management of, 2006; Piedimonte & Perez, 2014)

Respiratory syncytial virus is the most common virus causing bronchiolitis and pneumonia in children younger than 1 year old in Malaysia and also worldwide (Griffiths, Drews, & Marchant, 2017; Ngeow et al., 1997). In the United States the second common organism is human rhinovirus (Mansbach, Piedra, Teach, et al., 2012). In Malaysia, the second most common virus is the influenza virus (Chan, Goh, Chua, Kharullah, & Hooi, 1999; Rahman, Wong, Hanafiah, & Isahak, 2014). However, in these local studies, polymerase chain reaction (PCR) techniques were not used to detect rhinovirus, hence possible underreporting of the importance of rhinovirus in the aetiology of bronchiolitis. Interestingly, 30% of children with acute bronchiolitis have more than 1 pathogen detected in their nasal secretions(Mansbach, Piedra, Stevenson, et al., 2012).

Bronchiolitis has been reported to be common during the winter season in temperate climates (Birkhaug et al., 2013; Mansbach, Piedra, Stevenson, et al., 2012). However in Malaysia, although it is prevalent throughout the year, there are peaks of acute bronchiolitis occurring in the months from November to January each year.

Pneumonia and bronchiolitis are most common causes of admission for lower respiratory tract infections in young children in Malaysia(Chan et al., 1999). It is the leading cause of infant hospitalization in United States(Leader & Kohlhase, 2003), with 17% of hospitalisation in infants (9 admission per 100 child) in state of New York (McConnochie, Roghmann, & Liptak, 1995) and a nearly 150,000 admissions annually in United States(Pelletier, Mansbach, & Camargo, 2006). The mean length of stay (in United States) for acute bronchiolitis is 3.3 days with an annual costs of US 543 million dollars for bronchiolitis related hospitalisation, and a mean cost of US 3799 dollars per hospitalization(Pelletier et al., 2006).

Acute bronchiolitis is a dynamic illness, which requires frequent assessment of the respiratory status. Although majority of the patients have a self-limiting condition and can be treated as outpatient, severe cases will need frequent monitoring and intervention, some will even need ventilator support and intensive care(Green et al., 2016). Patients aged less than 3 months, born premature, with chronic lung disease, congenital heart disease or immunodeficiencies, are at higher risk of developing more severe disease are. (Fernandes et al., 2015)

Recognition of the severity of disease and initiation of accurate treatment is crucial. Pulmonary function test which best describes the lung status is impossible to be done in clinical practice, especially in young children with bronchiolitis, as pulmonary function test is dependent on the child's ability to actively exhale(Bekhof, Reimink, & Brand, 2014). While infant lung testing does exist, it is mainly used for research purposes. Hence, clinical judgments are important in triage and monitoring these ill children. Decision to admit for close monitoring, oxygen therapy, fluid management and regular suction is important, as failure to detect patients who require the above treatment can

cause morbidity and mortality. On the other hand, unnecessary admission can cause financial, social and mental burden to patient, family members and hospital staff. It is important to have guidance for assessment of severity of acute bronchiolitis and this will also make assessment more accurate and reliable.

A validated respiratory scoring system can guide to detect severity of the disease and subsequently contribute to good clinical management (Liu et al., 2004; Luarte-Martinez, Rodriguez-Nunez, Astudillo, & Manterola, 2017). Respiratory scoring systems are important tools to assess respiratory status, both clinically and in research. Respiratory scores can be used to assess initial respiratory status, follow trends during the illness and also evaluate response to therapeutic interventions and non-therapeutic interventions.

There are many respiratory scoring systems available for acute bronchiolitis. They differ in the components of assessment, complexity of assessments and scoring range. The main components these respiratory scoring systems are: respiratory rates, heart rates, breaths sounds, retractions, general conditions and oxygen requirements.

The examples of respiratory scoring systems are as below:

1. **Kristjansson Respiratory Score**
2. Wang Respiratory Score
3. Respiratory Distress Assessment Instrument
4. **Children's Hospital of Wiscousin Respiratory Score**
5. Bronchiolitis Severity Score
6. Tal and Modified-Tal Scoring System
7. ReSVinet Scale
8. Acute Bronchiolitis Severity Scale

Below is a summary of available scoring system:

	Scores	Components	Total scores
Kristjansson Respiratory Score	0-2	Respiratory rate, Breath sounds, Skin Colour, Recessions, General condition	0-10
Wang Respiratory Score	0-3	Respiratory rate, Wheezing, Recessions, General condition	0-12
Respiratory Distress Assessment Instrument	0-4	Wheezing (expiration, inspiration, location), Recessions(supraclavicular, intercostal, subcostal), Respiratory rate	0- 17
CHWRS	0-3	Breath sounds, Dysnea, Recessions, Respiratory rate, Heart rate, Oxygen need, Activity, Cough/secretions, CXR/Lung sounds, Surgical status	0-30
Bronchiolitis Severity Score	0-3	Respiratory rate, Wheezing, Recessions, General condition	0-12
Modified Tal	0-3	Respiratory rate, Wheezing, Oxygen saturation, accessory muscle	0-12
ResVinet scale	0-3	Feeding intolerance, Medical intervention, Respiratory difficulty, Respiratory rate, Apnea, General condition, Fever	0-20
Acute Bronchiolitis Severity Scale	0-4	Wheezing, Crackles, Effort, I:E ratio, Respiratory rate, Heart rate	0-17

Table 1: Summary of existing scoring methods for children

Chapter 2.1: Types of respiratory scoring system

Chapter 2.1.1: Kristjansson Respiratory Score

Kristjansson Respiratory Score(KRS) was designed by none other than Kristjansson himself, during a study entitled Nebulised Racemic Adrenaline In The Treatment Of Acute Bronchiolitis In Infants And Toddlers.(Kristjansson, Lodrup Carlsen, Wennergren, Strannegard, & Carlsen, 1993) This study was conducted to compare nebulisation of adrenaline versus placebo in young children with bronchiolitis. The Kristjansson Respiratory Score was used to assess the respiratory status before treatment and every 15 minutes after treatment, until 1 hour post treatment.

The Kristjansson Respiratory Score composes of 5 components (Respiratory rate, Breath sounds, Skin Colour, Recessions, General condition) and each component is rated from 0 to 2 points, bringing it to maximum of 10 points. The breath sounds component, which is composed of vesicular breathing, wheeze or severe wheeze, might differ according to assessor. We also noted that assessment of recessions is difficult to assess as in this scoring system, it scores 0 points for no recession, 1 point for moderate recession but no score for mild recession. Hence, the presence of costo-diaphragmatic recessions will be taken as moderate recession.

Kristjansson Respiratory Score					
Score	**Respiratory rate (Breaths/min)**	**Chest Recession**	**Breath Sound**	**Skin Colour**	**General Condition**
0	<40	None	Vesicular	Normal	Not affected
1	40-60	Moderate (Costodiaphragmatic)	Wheeze =/- rhonchi/rale	Pallor	Moderately affected
2	>60	Severe (as in 1 plus rib and Jugular retraction)	Severe wheeze =/- rhonchi/rale	Cyanosis	Severely affected

Figure 1: Kristjansson Respiratory Score

Chapter 2.1.2: Wang Respiratory Score

The Wang Respiratory Score(WRS) was created in 1992 by Wang et al for a study entitled Observer Agreement for Respiratory Signs and Oximetry in Infants Hospitalized with Lower Respiratory Infections. (Wang, Milner, Navas, & Maj, 1992) It was again used in the Wang et al study on Bronchodilators For Treatment Of Mild Bronchiolitis: A Factorial Randomised Trial. (Wang, Milner, Allen, & Maj, 1992)

It is composed of 4 components and each component is rated from 0 to 3 points, bringing it to maximum of 12 points. The recession component is more specific than the KRS score as intercostal recession is1 mark, trachea-sternal recession is 2 marks and severe recession with nasal flaring is 3 marks, but no marks are given for subcostal recessions. We also noted that the wheezing component is more complicated, as it requires specific auscultation whether is terminal expiration rhonchi (with stethoscope), entire rhonchi (with stethoscope) or audible wheeze (without stethoscope) which may result in a high interobserver variation.

Wang Respiratory Score				
Score	**Respiratory Rate**	**Wheezing**	**Retraction**	**General Condition**
0	<30	None	None	Normal
1	30-45	Terminal expiration or only with stethoscope	Intercostal recession	
2	45-60	Entire expiration or audible on expiration without stethoscope	Trachea-sternal recession	
3	>60	Inspiration and expiration without stethoscope	Severe with nasal flow	Irritable/ Lethargic/ Poor feeding

Figure 2: Wang Respiratory Score

Chapter 2.1.3: Respiratory Distress Assessment Instrument

Respiratory Distress Assessment Instrument (RDAI) was developed for a study done by Darcy I et al entitled Wheezing in infants: The response to epinephrine.(Lowell, Lister, Von Koss, & McCarthy, 1987) The study was a double-blind, randomized trial using subcutaneous epinephrine versus normal saline conducted at Yale-New Haven Hospital, in children less than 24 months old, who presented with wheezing. The RDAI was used to assess the severity of illness before and after treatment.

Respiratory Distress Assessment Instrument has 2 main components: wheezing and recessions. The wheezing component is further subdivided to expiration, inspiration and location. For the wheezing component, it requires assessment of which part of respiration is the wheeze present: part, half or throughout expiration and inspiration phase, which again may be difficult to assess and might not be heard during severe obstruction case.

Respiratory rate which has proven to be a very important component for assessment, is also not included in this assessment component, but is taken as an assessment tool as a dimensional variable.

Respiratory Distress Assessment Instrument					
	0	**1**	**2**	**3**	**4**
Wheezing					
Expiration	None	End	½	¾	All
Inspiration	None	Part	All		
Location	None	Segmental: <2 of 5 lung fields	Diffuse: >3 of 4 lung fields		
Retractions					
Supraclavicular	None	Mild	Moderate	Marked	
Intercostal	None	Mild	Moderate	Marked	
Subcostal	None	Mild	Moderate	Marked	

Figure 3: Respiratory Distress Assessment Instrument

Chapter 2.1.4: REsVinet Scale

REsVinet Scale is a new respiratory scoring system for infants with acute respiratory infections which was published in June 2016(Justicia-Grande et al., 2016). It is composed of 7 components: Feeding intolerance, medical intervention, respiratory difficulty, respiratory frequency, apnea, general condition and fever and most components are rated from 0-3 points (except apnea which is rated either 0 or 3 points and fever either 0-2 points) giving a maximum of 20 points. Interestingly. it is a new scoring system that takes into account mostly history of symptoms but not examination findings, hence perhaps obviating the problem of interobserver variability .

ReSVinet Scale				
Item	**0**	**1**	**2**	**3**
Medical Intervention	No	Mild	Partial	Total
Feeding intolerance	No	Basic	Intermediate	High
Respiratory difficulty	No	Mild	Moderate	Severe
Respiratory frequency	Normal	Mild or occasional tachypnea	Prolonged or recurrent tachypnea	Severe alteration
Apnea	No			Yes
General condition	Normal	Mild	Moderate	Severe
Fever	No	Yes, mild	Yes, moderate	

Figure 4: ResVinet Scale

Chapter 2.1.5: Tal and Modified Tal Scoring System

Tal(TRS) and Modified Tal(MTAL) scoring system was devised by Bierman et al. for asthma and modified by Tal et al.(Tal et al., 1983) It consist of 4 components (respiratory rate, wheezing, recessions and Spo2) and each component is rated from 0-3 points. Assessment of cyanosis in Tal Scoring system is complicated which is simplified in Modified Tal Scoring System. In both the scoring systems, the wheezing component is quite complicated, as it needs to be differentiated between terminal expiratory or entire inspiration.

A prospective cohort study conducted by McCallum G et al entitled Severity Scoring Systems: Are they internally valid, reliable and predictive of oxygen use in children with acute bronchiolitis in year 2012. (McCallum et al., 2013) was done to determine the validity and reliability of Tal and modified Tal scoring system and also to assess whether modified Tal Scoring System can predict the need for oxygen at 12 and 24 hours post diagnosis. A total of 138 children aged below 24 months, with clinical

diagnosis of acute bronchiolitis, were recruited. Children were assessed by 2 different staff nurses with both Tal and Modified Tal Scoring System. Results showed that the Modified Tal Scoring System had good internal consistency. Both Tal and Modified Tal Scoring System have good inter-rater reliability. However, both Tal and Modified Tal Scoring System were still unable to predict oxygen requirement at 12 and 24 hours.

Tal Scoring System				
Score	**Respiratory rate (breaths/min)**	**Wheeze**	**Cyanosis**	**Accessory respiratory muscle utilization**
0	<30	None	None	None
1	30-45	Terminal expiration only	Peri-oral on cyring only	Presence of mild intercostal in-drawing
2	45-60	Entire expiration and inspiration with stethoscope only	Perioral in rest	Moderate amount of intercostal in-drawing
3	>60	Entire expiration and inspiration without stethoscope only	Generalized in rest	Moderate or marked intercostal indrawing with presence of head bobbing or tracheal tug

Figure 5: Tal Scoring System

Modified-Tal Scoring System				
Score	**Respiratory rate (breaths/min)**	**Wheeze**	**Cyanosis**	**Accessory respiratory muscle utilization**
0	<30	None	>95	None
1	30-45	Terminal expiration only	94-95	Presence of mild intercostal in-drawing
2	45-60	Entire expiration and inspiration with stethoscope only	90-93	Moderate amount of intercostal in-drawing
3	>60	Entire expiration and inspiration without stethoscope only	<89	Moderate or marked intercostal indrawing with presence of head bobbing or tracheal tug

Figure 6: Modified-Tal Scoring System

Chapter 2.1.6: Children's Hospital of Wisconsin Respiratory Scoring System

Children's Hospital of Wisconsin Respiratory scoring system was created by a panel of local clinicians and respiratory therapists in Children's Hospital of Wisconsin to assess severity of illness in acute bronchiolitis children. (Destino et al., 2012)

It is first published and validated in a study done in year 2012 by Destino, W. et al to assess validity and reliability of Children's Hospital of Wisconsin Respiratory score(CHWRS) and Respiratory distress assessment instrument(RDAI) and also to identify the components in these respiratory systems that can best used to assess severity of respiratory status.(Destino et al., 2012)

It consists of 10 components and each component has 3 points. It is a scoring system with a very broad assessment including many parameters, as it includes assessments needed to assess severity of disease progression. However, it has a surgical status component which is rarely seen in children with acute bronchiolitis.

While this is all inclusive, it may make the scoring more difficult to use, even in clinical studies.

Children's Hospital of Wisconsin Respiratory Score				
	0	1	2	3
Breath sounds	Clear	Rales/ crackles	Insp wheeze	Poor air entry
		Exp wheeze	Insp and exp wheeze	Marked wheeze
		Rhonchi/Coarse		
		Prolong exp phase		
Dyspnea	None	Occasional break with feeds	Frequent breaks with feed	Unable to feed
		Complete sentences	Phrases	Single words
		Minimal increase work of breathing	Some increase work of breathing	Significant increase work of breathing
Retractions	None	Mild	Moderate	Severe
Respiratory Rate	<50	51-60	61-70	>71
Heart Rate	<150	151-160	161-170	>171
Oxygen Need	RA	< 2L/min nasal cannula	2.5-4 L/min nasal cannula	>4.5L/min nasal cannula
		5-6 L/min face mask	>6.5 L/min face mask	Not applicable
		< 0.3 FiO2	0.31- 0.5 FiO2	>0.51 FiO2
Activity appearance	Calm, content	Mildly irritable	Moderately irritable	Severely irritable
	Happy interactive	Able to console, position self	Difficult to console, less interactive	Unable to console, not interactive
Cough ability/ secretions	Strong non productive cough	Strong productive cough	Weak cough	Requires suctioning to stimulate cough and remove secretions
	Minimal	Moderate-large	Large	
Chest X-ray/ Lung sounds	Clear	Hilar or central area	One lobe	Multiple lobes
	Bronchial	Bronchial in 1 lobe	Reduce in 1 lobe	Reduce in multiple lobes
Surgical Status	No surgery Cath lab Bronchoscopy	Extremity or neurosurgery with normal neurologic exam	Abdominal or neurosurgery with abnormal neuro exam	Thoracic spinal airway

Figure 7: Children's Hospital of Wisconsin Respiratory Score

Chapter 2.1.7: Acute Bronchiolitis Severity Scale

Acute Bronchiolitis Severity Scale was established and validated in 2014 by Ramos Fernandez et al. (Ramos Fernandez, Cordon Martinez, Galindo Zavala, & Urda Cardona, 2014) This study recruited 75 patients who are admitted for acute bronchiolitis. Each patient was assessed by 2 doctors, either first year residents, second year residents or physicians using this score.

Acute Bronchiolitis Severity Scale is composed of 6 components: wheezing, crackles, effort, inspiratory: expiratory ratio, respiratory rate and heart rate. Wheezing and crackles component is rated 0 to 4 points, effort is rated 0 to 3 points, while inspiratory: expiratory ratio, respiratory rate and heart rate is rated from 0 to 2 points.

The superiority of this scoring system is that respiratory rate and heart rate is categorised depending on normal for the age. However, as in most studies, wheezing, crackles and inspiration:expiration ratio are still difficult to assess and may result in inter-observer variability. The mean inter-rater reliability is good, kappa score of 0.7745 with the best score for respiratory rate followed by effort then wheezing. The lowest inter-reliability score is inspiration:expiration ratio. This shows that inspiration:expiration ratio is difficult to assess.

Acute Bronchiolitis Severity Scale					
Score	**0**	**1**	**2**	**3**	**4**
Wheezing	No	Wheezing at the end of expiration	Wheezing throughout expiration	Inspiratory-expiratory wheezing	Hypoventilation
Crackles	No	Crackles in one field	Crackles in 2 fields	Crackles in 3 fields	Crackles in 4 fields
Effort	No	Subcostal or lower intercostal retractions	Suprasternal retractions or nasal flaring	Nasal flaring and suprasternal (universal)	
Inspiration: Expiration Ratio	Normal	Symmetrical	Inverted		
Respiratory Rate					
Age					
< 2 months	<57	57-66	>66		
2-6 months	<53	53-62	>62		
6-12 months	<47	47-55	>55		
Heart Rate					
Age					
7 days- 2 months	125-152	153-180	>180		
2- 12 months	120-140	140-160	>160		

Figure 8: Acute Bronchiolitis Severity Scale

Chapter 2.2: Literature Review on Comparison of Respiratory Scoring System

There are multiple studies done to validate respiratory scoring systems, compare efficacy of different scoring systems and also systemic review and meta-analysis to assess respiratory scoring systems.

These studies also assess components of scoring system best to assess severity of illness.

Chapter 2.2.1: Comparison of Heart Rate Versus Pulse Oximetry as a tool for assessment

Looking at all the respiratory scoring system listed above, we can see that most scoring system uses SpO^2 (saturation) as one of the components to assess the severity of illness. Only the Children's Hospital of Wisconsin Respiratory Score uses both respiratory rate and heart rate.

A study conducted by Rodriguez, H. entitled "A simple respiratory severity score that may be used in evaluation of acute respiratory infection", published in 2016(Rodriguez, Hartert, Gebretsadik, Carroll, & Larkin, 2016), used the modified Modified Tal Scoring System to compare a respiratory score which exclusively involved physical examination components to compare original Modified Tal Scoring System, which uses pulse oximetry. The modified scoring system is named as RSS-HR, where the SpO^2 component of Modified Tal Scoring System was change to heart rate, as shown below; while the original Modified Tal Scoring System was label as RSS-SO.

The study recruited 497 infants who presented with acute respiratory illness during winter respiratory viral illness seasons between year 2004 and 2008. Each recruited infant was assessed by both RS-HR and RSS-SO.

This study showed that RSS-HR had a higher median score than the RSS-SO, for infants who are hospitalized. Both RSS- HR and RSS-SO had higher median scores for infants who required hospitalization compared to those who didn't.

This study also compared median scores for upper and lower respiratory tract infection. Both RSS-HR and RSS-SO had higher median scores for lower respiratory tract infection compared to upper respiratory tract infection, but RSS-HR had higher median scores compare to RSS-SO.

This study concluded that RSS-HR distinguishes severity of disease and was able to identify lower respiratory tract infections better.

Modified-Tal Scoring System (RSS-HR)				
Score	**Respiratory rate (breaths/min)**	**Wheeze**	**Heart Rate**	**Accessory respiratory muscle utilization**
0	<30	None	<150	None
1	30-45	Terminal expiration only	151-160	Presence of mild intercostal in-drawing
2	45-60	Entire expiration and inspiration with stethoscope only	161-170	Moderate amount of intercostal in-drawing
3	>60	Entire expiration and inspiration without stethoscope only	>170	Moderate or marked intercostal indrawing with presence of head bobbing or tracheal tug

Figure 9: RSS-HR, modified Modified Tal Respiratory Scoring System

Modified-Tal Scoring System (RSS-SO)				
Score	**Respiratory rate (breaths/min)**	**Wheeze**	**Cyanosis**	**Accessory respiratory muscle utilization**
0	<30	None	>95	None
1	30-45	Terminal expiration only	94-95	Presence of mild intercostal in-drawing
2	45-60	Entire expiration and inspiration with stethoscope only	90-93	Moderate amount of intercostal in-drawing
3	>60	Entire expiration and inspiration without stethoscope only	<89	Moderate or marked intercostal indrawing with presence of head bobbing or tracheal tug

Figure 10: RSS-SO, Original Modified Tal Scoring System

Chapter 2.2.2: Respiratory scoring system as tool for assisting assessment of severity of illness

In a study published by Howard M. Corneli et al in 2012 entitled : "Clinical Characteristic Associated with Hospitalization and Length of Stay"(Corneli et al., 2012), data on respiratory scoring was collected as a part of a randomized controlled trial, looking at the use of dexamethasone for bronchiolitis(Corneli et al., 2007), aimed to identify if initial presenting clinical characteristic were associated with admission and length of hospital stay. Longer length of hospital stay was defined as duration for more than 1 night.

This study was conducted in 20 emergency departments from January 2004 to April 2006 (conducted during bronchiolitis seasons from November to April). Patients aged 2 to 12 months with first time presentation for acute bronchiolitis, with a score of Respiratory Distress Assessment Instrument (RDAI) 6 or greater were recruited. The original study was conducted as a randomized study where patients received oral dexamethasone or placebo and unfortunately, no treatment effect was demonstrated.

A total of 598 infants were recruited into this study, 240 patients require hospitalization, 159 require longer length of stay.

From this study, SpO^2 was the best predictor for admission and longer length of stay, if the initial SpO^2 was less than 94%, followed by RDAI score of more than 11 and next was a respiratory rate more than 60.

Respiratory rate is included in almost all scoring systems; this study showed that scoring systems are a good at assessing severity of acute bronchiolitis.

In another study done by Feldman A et al entitled Respiratory Severity Score separates Upper Versus Lower Respiratory Tract Infections and Predicts Measures of Disease Severity in year 2015. (Feldman et al., 2015) used the Modified Tal Scoring System to assess patients who present with acute respiratory illness to Vanderbilt Children's

Hospital from year 2004-2008. Included were 630 patients who fulfilled of one of three major criteria (wheeze, retraction, dyspnea) and at least 2 minor criteria (fever, rhinorrhea, cough, otitis media, hoarse cry, post tussive vomiting, RSV test).

From this study, respiratory score was higher in infants hospitalized versus those who received outpatient treatment. Respiratory score was also higher for patients with a lower respiratory tract infection compare to an upper respiratory tract infection.

Langley J et al in a randomized controlled trial, looking at the use of racemic epinephrine compared to salbutamol, in hospitalized young children with bronchiolitis.(Langley et al., 2005) recruited patients aged 6 weeks to 2 years old who presented with wheezing and were diagnosed with acute bronchiolitis. In this study, patients received aerosolized racemic epinephrine or salbutamol 1-4 hourly. Respiratory Distress Assessment Instrument (RDAI) was used to assess the response to treatment. Outcomes assessed were improvement in RDAI score, length of stay, adverse events and report of symptoms (via phone) 1 week after discharge. A total of 62 children were recruited. The study showed that racemic epinephrine improved wheezing, oxygen saturation and RDAI score on second and third day of hospital stay, compared to salbutamol. However, there was no significant difference in the length of stay.

Chapter 2.2.3: Assessor for Scoring System

Multiple Respiratory Scoring Systems have been established to assist in assessing the severity of respiratory illness. Studies have also been done to assess inter-rater reliability between assessors: respiratory therapist, staff nurses, pediatricians, medical officers, house officers and even medical students (4^{th} and 5^{th} years).

Ho Jen Chin et al from Department of Paediatrics, Hospital Universiti Sains Malaysia(HUSM) and Hospital Kota Bahru (HKB) in year 2004, compared the Kristjansson Respiratory Score and Wang Respiratory Score, (Chin & Seng, 2004) particularly the validity of both Kristjansson Respiratory Score and Wang Respiratory Scores by correlating the scores with oxygen saturation in room air and also to assess the inter-rater reliability.

Children recruited in HUSM were assessed using the Kristjansson Respiratory Score while those from HKB were assessed using Wang Respiratory Score. Each patient was assessed by 2 assessors using the same respiratory scoring system. The first observer was the main investigator and the second observer was a pediatrician, pediatric medical officer, house officer or medical student (4^{th} and 5^{th}) year.

This study showed that both scoring systems have a high inter-rater reliability but Wang Respiratory Score (ICC 0.99) showed higher inter-rater reliability compare to Kristjansson Respiratory Score (ICC 0.89). Among the Kristjansson Respiratory Score, respiratory rate had the highest inter-rater reliability followed by general condition, chest recession, breath sounds than skin colour. While for Wang Respiratory Score, wheezing and general condition had the highest inter-rater reliability.

Many studies have used research nurses as assessor. The study by McCallum G et al used 2 different staff nurses with varying levels of experience with both Tal and Modified Tal Scoring System. Both the Tal and Modified Tal Scoring System had good inter-rater reliability (Kappa score 0.70 for Modified Tal and 0.72 for Tal). The highest

reliability score was for Spo2 (using machine to measure) followed by cyanosis, wheezing, assessory muscle use and the lowest reliability score is for respiratory rate.

The other studies that used nurses as assessor were:

1. Lowell, D et al study on Wheezing in Infants: The response to epinephrine. (Lowell et al., 1987)
2. Langley, J. et al study on Racemic Epinephrine compared to salbutamol in hospitalized young children with bronchiolitis; a randomized controlled trial clinical trial. (Langley et al., 2005)
3. Wang, E. et al study on Bronchodilators for treatment of mild bronchiolitis: A factorial randomised trial. (Wang, Milner, Allen, et al., 1992)

Chapter 2.2.4: Comparison of Scoring System

A prospective cohort study was done at Children's Hospital of Wisconsin by Lauren Destino et al (Destino et al., 2012) in year 2012.

This study was conducted to establish the validity and reliability of **Children's Hospital of Wisconsin Respiratory score (CHWRS)** and **Respiratory distress assessment instrument (RDAI)** and to identify the component in these respiratory systems that can best used to assess severity of respiratory status.

This study showed that RDAI has relatively poor inter-rater reliability, this could be due to respiratory therapists are more familiar with CHWRS scoring system as CHWRS scoring system had been used in the hospital for longer period. RDAI had been shown to have good inter-rater reliability in a previous study.(Fernandes et al., 2015)

Although CHWRS has more components for assessment, time used to complete each respiratory scoring system was reported to be same; this is as the wheezing components of RDAI is more complicated and require more time to complete.

Both scores have poor correlation with length of stay. CHWRS (Area under receiver operating curve was 0.68 compare to RDAI of 0.51) was found to be more effective in identifying patients who require admission. The important elements in both scoring systems in assessing severity of illness are oxygen need, respiratory rate and subcostal recessions.

Another study conducted at the Department of Paediatrics, Hospital Universiti Sains Malaysia (HUSM) and Hospital Kota Bahru (HKB) by Ho Jen Chin et al in year 2004. (Chin & Seng, 2004) This study was conducted to study the validity of both Kristjansson Respiratory Score and Wang Respiratory Score by correlating the scores with oxygen saturation in room air and also to assess the inter-rater reliability.

Children in HUSM were assessed using the **Kristjansson Respiratory Score** while those from HKB were assessed using **Wang Respiratory Score.** Each patient was assessed by 2 assessors using the same respiratory scoring system.

This study shows that Kristjansson Respiratory Scoring system has a better correlation with Spo2 compare to Wang Respiratory Score. Among element in the respiratory score, general condition component of both Kristjansson and Wang Respiratory Score has the strongest correlation with Spo2, while respiratory rate has the lowest correlation with Spo2.

This study also shows that both Kristjansson and Wang Respiratory Scoring System has high inter-rater reliability but Wang Respiratory Score has a slightly higher reliability than Kristjansson Respiratory Score.

The author concluded that validity of Kristjansson Respiratory Score is better than the Wang Respiratory Score, and general condition and chest recession components in Kristjansson Respiratory Score were the best indicators for assessing the severity of illness.

After comparing scoring systems available and studies above, we chose the Children's Hospital of Wisconsin Respiratory score (CHWRS) and Kristjansson respiratory score to compare. CHWRS has a total of 10 components and each component has highest of 3 points, giving maximum of 30 points, on the other hand Kristjansson scoring system consist of 5 components and each component has maximum 2 points, bringing to maximum of 10 points. This will enable us to compare a simple scoring system to a more complicated scoring system. Null hypothesis is both the chosen scoring systems are equally effective at determining pre-chosen clinical outcome.

Chapter 3: Objectives

Chapter 3.1 Primary Objective

To determine the discriminative ability of the 2 respiratory scores, Kristjansson and Children's Hospital of Wisconsin respiratory scores (CHWRS), at predicting admission

Chapter 3.2 Secondary Objectives

To:

3.2.1 correlate oxygen saturation at first time point with length of stay (LOS), admission and severity of illness.

3.2.2 correlate change in respiratory score within 24 hrs admission and LOS

3.2.3 determine Inter-rater reliability of both scores and individual components

3.2.4 determine association between aetiology and length of stay

3.2.5 Determine the discriminative ability of the individual components in predicting admission

Chapter 4: Methodology

Chapter 4.1 Study Design

This is a single center, cross-sectional study, involving children presenting to Pediatric Trauma, University Malaya Medical Centre from March 2017 to August 2017, with clinical features of acute bronchiolitis (defined as presence of cough and rhinorrhea with dyspnea and presence of wheezing).

University Malaya Medical Centre is a general hospital in Kuala Lumpur with 1068 beds. In University Malaya Medical Centre, there are a total of 130 pediatric beds, which includes 10 beds for pediatric intensive unit. Each general ward is equipped with a 4 bedded high dependency unit where most of the non- invasive ventilation is done. Medical ethical approval was obtained.

Chapter 4.2 Study Population: Inclusion and Exclusion Criteria

This study included patients aged from 1 month till 18 months, who present to Paediatric Trauma Centre, University Malaya Medical Centre from March 2017 till August 2017, with a diagnosis acute bronchiolitis. The symptoms include cough, rhinorrhea, difficulty in breathing and wheezing for duration less than 14 days. Patients were excluded if parents refused consent, in the presence of chronic lung disease or congenital heart disease, those with recurrent wheezing more than 2 episodes or those with a diagnosis of asthma.

Inclusion Criteria
Children aged 1-18 months Presenting with signs and symptoms of acute bronchiolitis or with doctor diagnosed acute bronchiolitis: - Cough - Duration less than 14 days - Difficulty in breathing - Wheezing or rhonchi
Exclusion Criteria
Underlying chronic lung or congenital heart disease Recurrent wheezing (more than 2 episodes) or has asthma

Table 2: Inclusion and Exclusion Criteria

Chapter 4.3 Training pre-study

Pediatric medical officers in the pediatric trauma were trained regarding this study. The presentation included details how the study will be done, details of data collection sheet, each scoring system, informed consent sheet and consent form.

Chapter 4.4 Data Collection and study flow

Once the patient was identified, informed written consent was obtained from parents. Two medical officers assessed the patients using the 2 scoring systems : Kristjansson respiratory scoring system and Children's Hospital of Winconsin Respiratory Score. Basic demographic data including presenting complaint, duration of illness, prior treatment for current illness, history of ill contact, exposure to tobacco smoke, history of wheezing, history and frequency of nebulization, family history, social history, birth history and family history of asthma were obtained.

As we were comparing the effectiveness of Kristjansson and Children's Hospital of Wisconsin Respiratory Scores in predicting admission, need for admission was the main outcome, which was determined by the emergency doctor in-charged.

To determine inter-rater reliability, each patient was assessed by 2 medical officers who used both the respiratory scores.

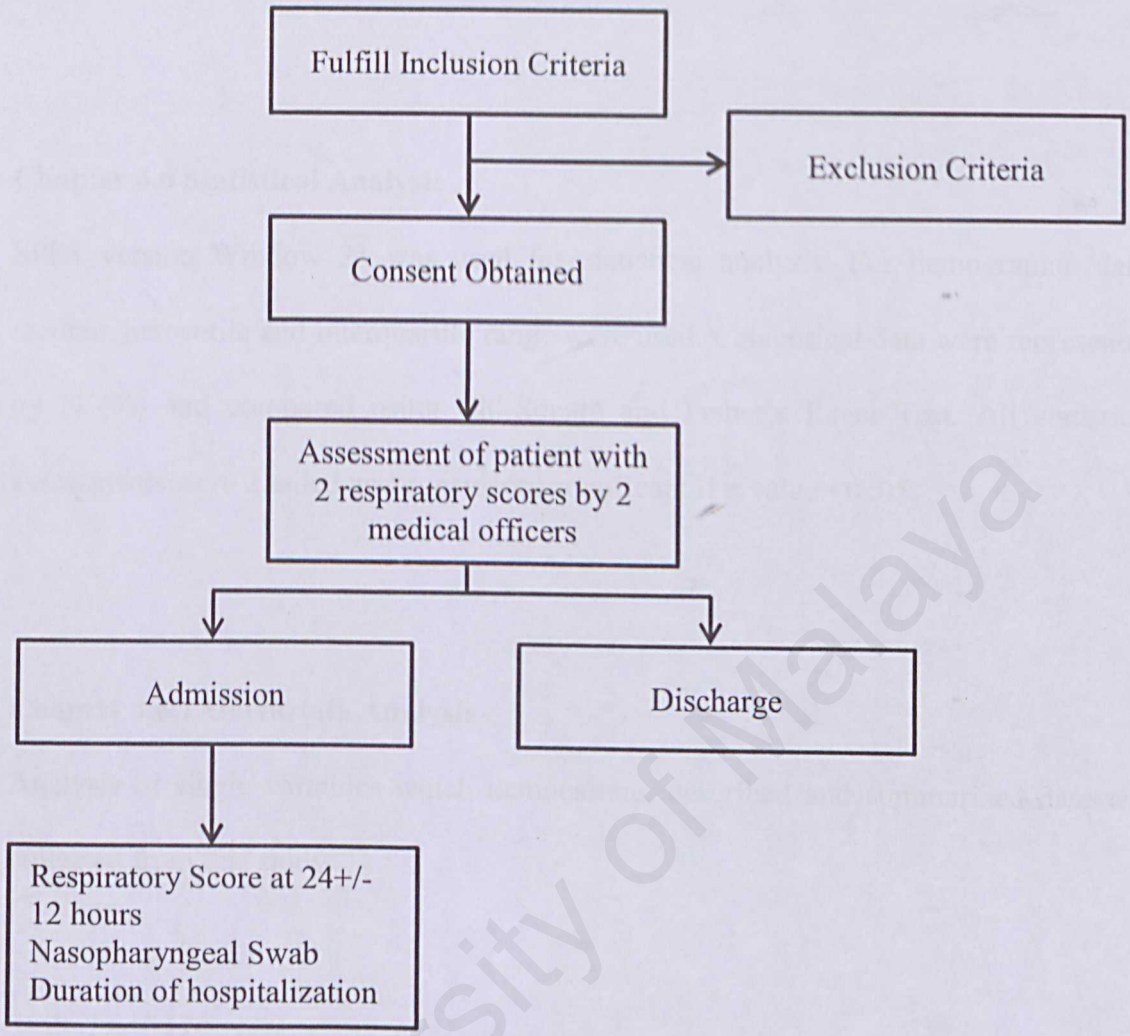

Figure 11: Flow Chart of Patient Recruitment

Chapter 4.5 Follow up

Patients who are admitted will be assessed again in the ward, within 24 hours from the first assessment as we wanted to see if the change in respiratory score within 24 hours of admission was associated with length of hospital stay. The assessment was done by 2 different medical officers, blinded to each other's assessment, using the 2 respiratory scores (Kristjansson respiratory scoring system and Children's Hospital of Wisconsin Respiratory Score). Nasopharyngeal culture and virology was collected during admission, as per normal practice. The length of stay, nasopharyngeal culture

nasopharyngeal virology, treatment received during admission and severity of illness was noted.

Chapter 4.6 Statistical Analysis

SPSS version Window 23 was used for statistical analysis. For demographic data, median, percentile and interquartile range were used. Categorical data were represented by N (%) and compared using Chi-Square and Fisher's Exact Test. All statistical assessments were 2 tailed and considered significant if p value <0 .05.

Chapter 4.6.1 Univariate Analysis

Analysis of single variables which demonstrate, described and summarized data was collected from this study.

Chapter 4.6.2 Bivariate Analysis

Correlation of changes in respiratory scores after 24 hours of admission and length of stay were analyzed using bivariate correlation analysis. Crosstab descriptive analysis was used to correlate saturation with admission and need of non-invasive ventilation support and length of stay with nasopharyngeal results.

Comparison of 2 respiratory score at predicting outcome was analyzed using area under receiver operator curve (aROC). aROC $\geq$0.75 is considered as clinically relevant. (Fan, Upadhye, & Worster, 2006) Inter-rater reliability was measured using intra-class reliability.

Mann-Whitney U test was used to compare saturation with length of stay.

Chapter 4.7 Ethical Considerations

This research was approved by Medical Ethic Committee, University Medical Centre MREC Ref No: 20161229-4713 (Appendix A). Patient information was anonymized and de-identified prior to analysis.

Chapter 5: Definitions

1. Acute bronchiolitis

   Lower respiratory tract infection caused by virus infection affecting small airways (bronchioles) with the following symptoms: Cough rhinorrhea, fever, tachypnea and wheezing.

2. Prematurity

   Neonates born less than 37 weeks of gestation. (American College of & Gynecologists' Committee on Practice, 2016)

3. "Out of home" care

   Child that is looked after by caregiver outside from home for more than 4 hours per day and at least 3 days per week, which could be in a daycare center, relative's house or nursery.

4. Environmental tobacco exposure

   Exposure to household cigarettes smoke for more than 4 hours per day

Chapter 6.1: Demographic Data

A total of 122 patients with clinical diagnosis of acute bronchiolitis were recruited from 10th March 2017 to 15th August. There were 2 patients who refused consent, 3 excluded for chronic lung disease and congenital heart disease and 2 excluded for symptoms more than 14 days. Seventy-four patients (60.7%) were male and 48 (39.3%) were females. (Figure 11)

Gender	Number	%
Female	48	39.3
Male	74	60.7
Total	122	100

Table 3: Gender distribution of patients recruited

Patients recruited in this study age ranged from 2 months to 18 months old with median (IQR) age of 9 (6,12) months old. (Figure 12)

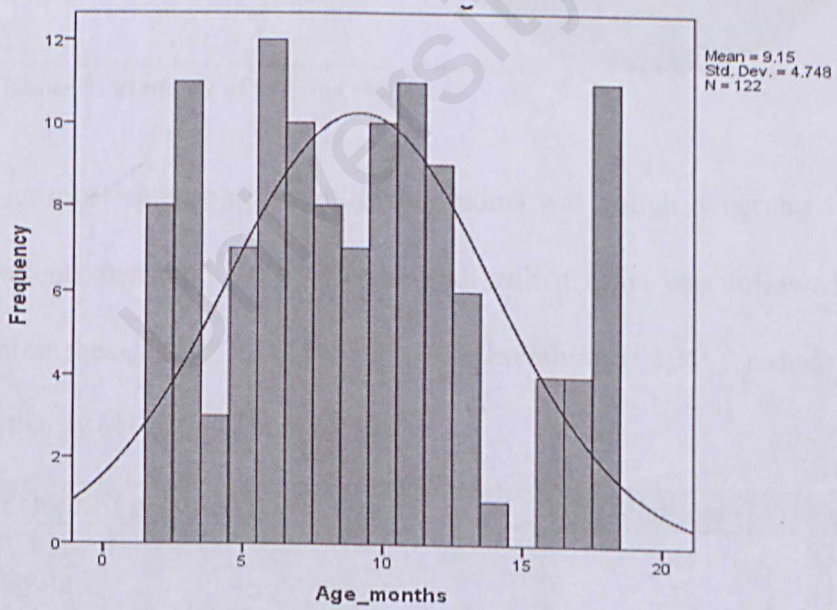

Figure 12: Age distribution of patients recruited

As for ethic origin, majority of the patients were Malay (91.8%), followed by Indian (4.9%), Chinese (0.8%) and others (2.5%). There was a marked over representation of Malays who make up 68.8% of the population and under representation of Chinese ethnicity who constitute 23.2% of the population. Other ethnics who include Indian ethnicity constitute 7%, same as 2017 statistic for Malaysia's ethnicity. (Embargo, 2017) (Figure 13)

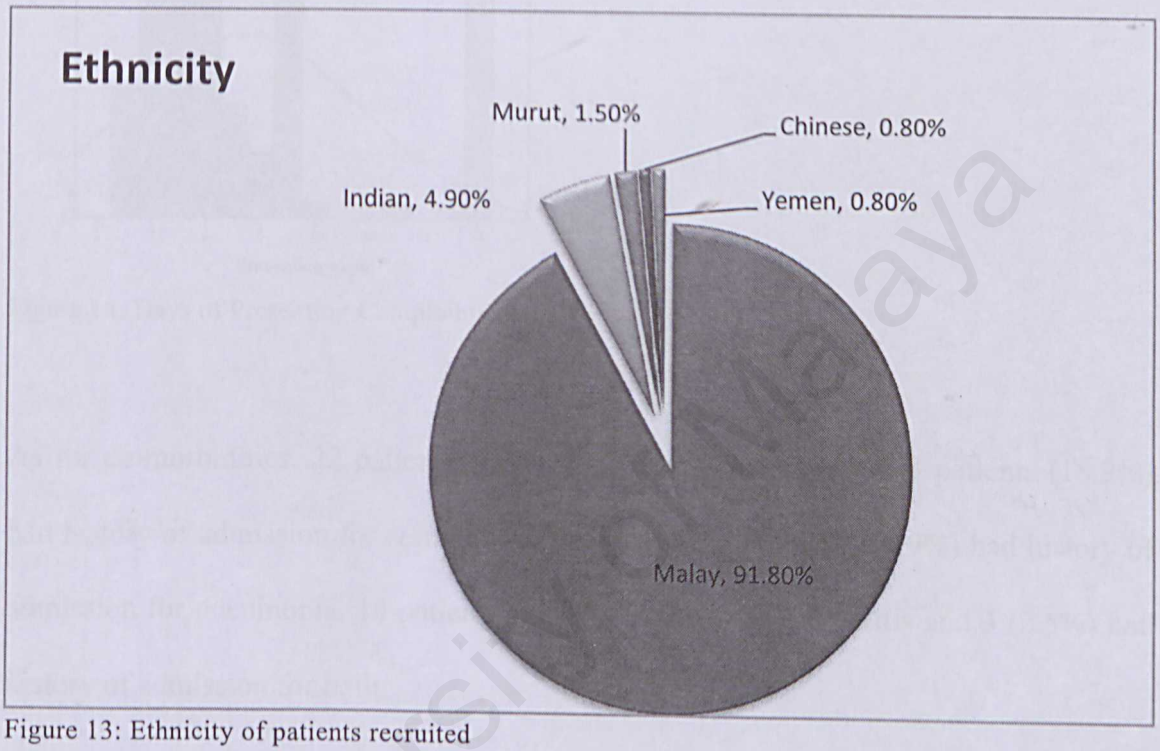

Figure 13: Ethnicity of patients recruited

The most common presenting symptoms was cough, whereby 120 patients out of 122 patients recruited (93.4%) presented with it. This was followed by dyspnea (83.6%), rhinorrhea (82.8), fever (68%), noisy breathing (62.3%), reduce oral intake (59%) and lethargy (41.8%). (Table 4)

Presenting symptoms	Percentage (%), N=122
Cough	93.4%
Dyspnea	83.6%
Rhinorrhea	82.8%
Fever	68%
Noisy Breathing	62.3%
Reduce Oral Intake	59%
Lethargy	41.8%

Table 4: Presenting Complaints

The duration of symptoms, until presentation to Paediatric Trauma, ranged from day 1 of illness till day 14 of illness, with peak at day 3 of illness.

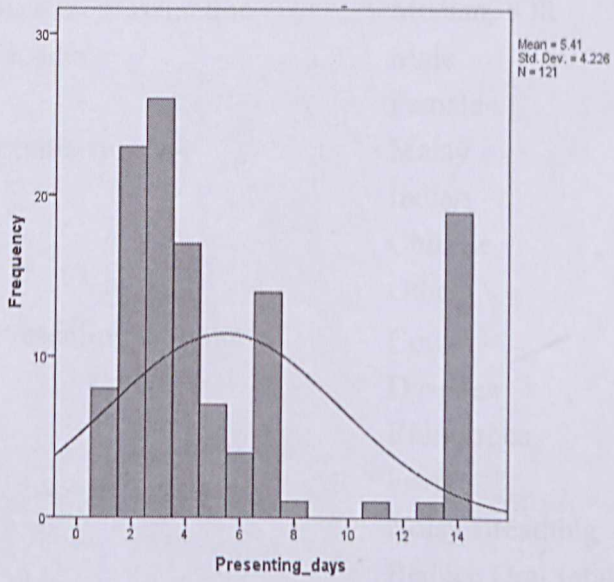

Figure 14: Days of Presenting Complaints

As for co-morbidities, 22 patients (18%) were born prematurely. 23 patients (18.9%) had history of admission for respiratory related illness. 6 patients (4.9%) had history of admission for pneumonia, 14 patients (11.5%) for acute bronchiolitis and 3 (2.5%) had history of admission for both.

Environmental and family history also played an important role. Forty-eight patients (39.3%) had environmental tobacco exposure, 60 patients (49.2%) had family history of asthma and 89 patients (73%) have out of home care. (Table 5)

Demographic characteristics		N=122	Percentage (%)
Age on presentation	Median, IQR	9(6,12)	
Gender	Male	74	60.7
	Female	48	39.3
Ethnicity	Malay	112	91.8
	Indian	6	4.9
	Chinese	1	0.8
	Others	3	2.5
Presenting Symptoms	Cough	120	98.4
	Dyspnea	102	83.6
	Rhinorrhea	101	82.8
	Fever	83	68
	Noisy Breathing	76	62.3
	Reduce Oral Intake	72	59
	Lethargy	51	41.8
Environmental tobacco Exposure		48	39.3
Family history of Bronchial Asthma		60	49.2
Out of Home Care		89	73
Gestation	Term	100	82
	Prematurity	22	18
Past Medical History	Previous Admission for Respiratory illness	23	18.9
	History of Wheezing	34	27.9
	History of Nebulization	62	50.8

Table 5: Demographic Data

Chapter 6.2: Treatment and Outcome at Pediatric Trauma (Table 6)

Among the 122 patients recruited, 85 patients (69.7%) were discharged and 37 patients (30.3%) were admitted.

Fourteen patients (16.4%) who were discharged, revisited Pediatric Trauma within 48 hours and 7 were (50%) were admitted.

Majority of patients (75.4%) received nebulization and suction as treatment during their visit to Pediatric Trauma. 29 patients (23.8%) received nebulization only and 1 patient (0.8) was discharged after reassurance.

The most common nebulization received is 3%, where 84 patients (68.8%) received. Other nebulization given were salbutamol saline (22.1%) and salbutamol: hypertonic saline (8.2%).

Details		N=122	Percentage (%)
Treatment Received at Pediatric Trauma	Nebulization only	29	23.8
	Nebulization and suction	92	75.4
	None	1	0.8
Type of Nebulization Received at Pediatric Trauma	Nebulization S3%	84	68.9
	Nebulization Salbutamol Saline	27	22.1
	Nebulization Salbutamol:S3%	10	8.2
	Nebulization Normal Saline	1	0.8
Outcome	Admit	37	30.3
	Discharge	85	69.7
Revisited Pediatric Trauma N=87	Revisited Pediatric Trauma	14	16.4
	Readmitted after Revisited Pediatric Trauma (X/14 revisited pediatric trauma)	7	50

Table 6: Treatment and Outcome at Pediatric Trauma

Chapter 6.3: Assessor (Table 7)

A total of 37 medical officers participated in this study as assessors. Among them, 22 (59.5%) were pediatric medical officers and 15 (40.5%) were emergency medical officers. A total of 318 assessments (159 pairs) were completed, 84.2% were completed by pediatric medical officers and 15.7% were completed by emergency medical officers.

All first assessors were pediatric medical officers of which 87% was done by the primary investigator. Fifty-nine percent of 2nd assessment at pediatric trauma was done by pediatric trained medical officers.

Details		N=122	Percentage (%)
Assessors	Total	37	100
	Pediatric Medical Officers	22	59.5
	Emergency Medical Officers	15	40.5
Assessment	Total	318	100
	Pediatric Medical Officers	268	84.2
	Emergency Medical Officers	50	15.7

Table 7: Assessors

The years of experience (year of start working as houseman) of first assessors in emergency department ranged from 3 to 9 years with a mean of 8.5 years.
Whereas for years of experience for second assessors in emergency department ranged from 3 to 14 years with a mean of 6.5 years.

Years of Experience	Percentage (%)	Cumulative Percentage (%)
First Assessors in ED		
3 years	4.1	4.1
5 years	4.9	9.0
8 years	3.3	12.3
9 years	87.7	100
Second Assessors in ED		
3 years	15.6	15.6
4 years	3.3	18.9
5 years	7.4	26.2
6 years	16.4	42.6
7 years	27.9	70.5
8 years	10.7	81.1
9 years	17.2	98.4
14 years	1.6	100
First Assessors in Ward		
9 years	100	100
Second Assessors in Ward		
3 years	9.8	32.4
4 years	2.5	40.5
5 years	0.8	43.2
6 years	5.7	62.3
7 years	4.9	78.4
8 years	0.8	81.1
9 years	4.9	97.3
14 years	0.8	100

Table 8: Years of Experience

Chapter 6.4: Treatment Modality and Outcome for Patients (Table 8)

The median (IQR) admission hours was 63 (36,112). Among 37 patients admitted, 26 patients (70.2%) required oxygen support, 9 patients (24.3%) required noninvasive ventilator support including optiflow, CPAP and BiPAP. 3 patients (8%) were admitted to PICU. Among patients recruited, there is none who required intubation.

Most common treatment received was nebulized hypertonic saline, used in 31 patients (66%), followed by nebulized salbutamol (14%) and nebulized atrovent (5.4%). Antibiotics was commenced in 25 patients (67%) and 7 patients (19%) were on steroids.

Details	N=37	Percentage (%)
Admission Hours (Median, IQR)	63	(36,112)
Oxygen Requirement in ward	26	70.2
Admission PICU	3	8
NIV Requirement	9	24.3
Require Antibiotic	25	67
Require Nebulized Salbutamol	14	37.8
Require Nebulized Atrovent	2	5.4
Require Nebulized Hypertonic Saline	31	66
Require Steroid Therapy	7	19

Table 9: Treatment Modality and Outcome for Inpatient Patients

Chapter 6.5: Nasopharyngeal Secretion (Table 9)

Forty-four patients (36.1%) had NPS taken, this includes 37 patients who were admitted and 7 patients who revisited Pediatric Trauma and admitted.

Thirty-eight (31.1%) nasopharyngeal secretion yielded positive results: 19 patients (43.3%) has positive result for 1 organism, and 19 (43.3%) has more than 1 positive organism.

Five patients (13.2%) had only positive virology result, 18 patients (47.4%) have positive bacterial result, 14 patients (36.8%) were infected by both virus and bacterial. One patient (2.6%) has only positive fungal result.

Respiratory Syncytial Virus (20.9%) remains the most common virus causing lower respiratory tract infections in children less than 18 months old. This data shows lower incident rate compare to previous data (Griffiths et al., 2017; Miller et al., 2013).

Haemphilus Influenza (23.9%) is the most common bacteria causing lower respiratory tract infection in children less than 18 month sold followed by *Staph aureus* (16.4%), *Streptococcal pneumoniae (*11.9%) and *Moraxella catarrhalis* (7.5%), which are common bacterial organisms causing lower respiratory tract infection in children (Khan, Priti, & Ankit, 2015; Simoes et al., 2006).

Nasopharyngeal Secretion	N=44	Percentage (%)
Taken	44	36.1
Positive Result	38	31.1
Positive 1 organism	19	43.3
Positive 2 organisms	10	22.7
Positive 3 organisms	8	18.2
Positive >3 organisms	1	2.3
	N=44	Percentage (%)
Positive Virology Result Only	5	11.3
Positive Bacteriology Result Only	18	40.9
Positive both Virology and Bacteriology Result	14	31.8
Positive Fungal Result	1	2.2
Types of Organism	N=38	Percentage (%)
Respiratory Syncytial Virus	14	20.9
Haemophilus Influenza	16	23.9
Staphylococcus Aureus	11	16.4
Streptococcus Pneumoniae	8	11.9
Moraxella catarrhalis	5	7.5
Metapneumovirus	4	6
E. Coli	2	3
Pseudomonas Aeruginosa	2	3
Influenza A	1	1.5
Adenovirus	1	1.5
Serratia	1	1.5
MRSA	1	1.5
Candida Species	1	1.5

Table 10: Nasopharyngeal Secretion Interpretation

Chapter 6.6: Primary Objective:

The primary objective of this study was to determine the discriminative power of 2 respiratory scores, Kristjansson and Children's Hospital of Wisconsin respiratory scores (CHWRS), at predicting admission

The median (IQR) score for Children's Hospital of Wisconsin Respiratory Score for patients who are admitted is 9 (6, 11) whereas median (IQR) score for patients who were discharged was 5 (3, 7). On the other hand, the median (IQR) score for Kristjansson Scoring System for patients who were admitted was 4 (3, 5) and 3 (2, 3) for patients who were discharged. (Table 10) Both scores were significantly higher for patients who required admission.

	Admit (N= 37)	Discharge (N=85)	Z score	P value
Children's Hospital of Wisconsin Respiratory score (Median, IQR)	9 (6,11)	5 (3,7)	-5.801	< 0.001
Kristjansson Scoring System (Median, IQR)	4 (3,5)	3 (2,3)	-4.736	<0.001

Table 11: Median Score for Admission and Discharge for Both Respiratory Score

As both scoring systems have different maximum scores, we divided the scores by the maximum score, to obtain the probability score, hence allowing the 2 scores to be comparable.

The Area under Receiver Operating Characteristic Curve (aROC curve) for predicting admission was 0.832 (95% CI 0.753, 0.855) for Children's Hospital Wisconsin Respiratory Score with a cutoff point of 5.5 (maximal sensitivity), giving a sensitivity of 86.5% and specificity of 65%. The aROC curve for Kristjansson Respiratory Score was

0.760 (95% CI 0.665, 0.855) with a cutoff point of 5 (maximal sensitivity) giving a sensitivity of 86.5% and specificity of 44.7%.

Children's Hospital Wisconsin Respiratory Score had a higher aROC and specificity than the Kristjansson Respiratory Score.

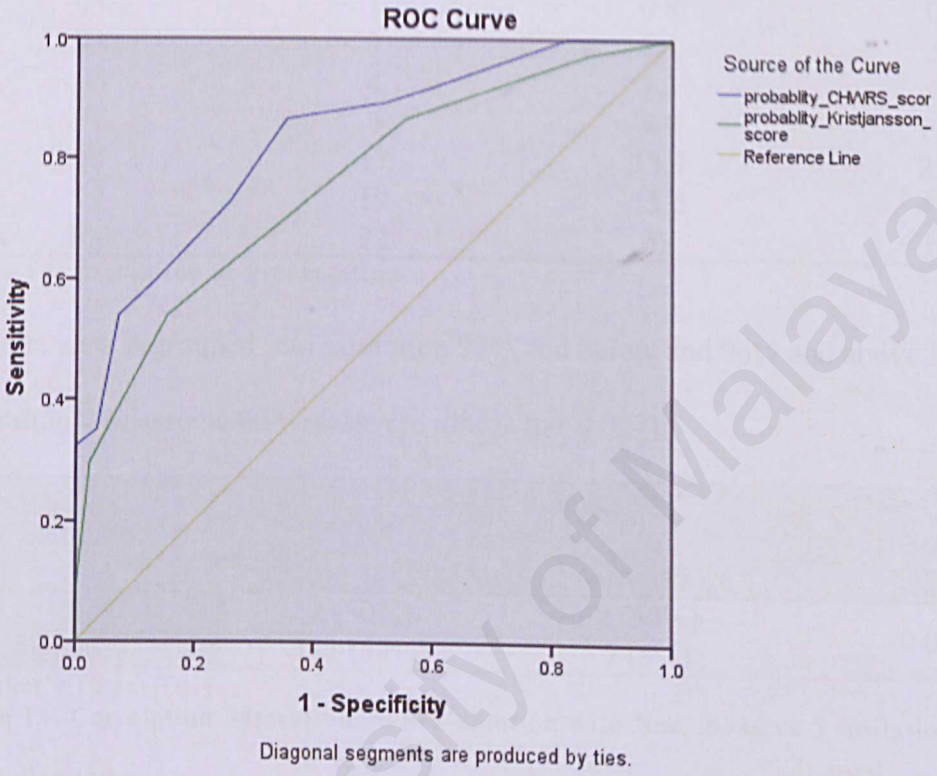

Figure 15: Area under receiver operating curve for CHWRS and KRS

Respiratory scores	Area	SE	Asymp. Significance (AS)	Asymptomatic 95% Confidence Interval		Sensitivity %	Specificity %
				Lower Bound	Upper Bound		
CHWRS	0.832	0.040	< 0.001	0.753	0.911	86	65
Kristjansson	0.760	0.049	< 0.001	0.665	0.855	86	47

SE: Standard Error; AS: Asymptomatic significance

Table 12: Respiratory Scores at Predicting Admission

Chapter 6.7: Secondary Objectives

Chapter 6.7.1: Correlation of oxygen saturation at first time point with length of stay (LOS), need for admission and severity of illness

Saturation (%)	Frequency	Percentage (%)	Cumulative Percentage (%)
93	1	0.8	0.8
95	3	2.5	3.3
96	4	3.3	6.6
97	6	4.9	11.5
98	17	13.9	25.4
99	19	15.6	41.0
100	72	59	100

Table 13: Saturation at Presentation

Patients were regrouped into saturation 95% and below and 96% and above, low saturation was associated with severe illness (p= 0.027).

Saturation	Severe illness		P value
	No (n =113)	Yes (n= 9)	
≤ 95%	2 (50%)	2 (50%)	0.027*
≥ 96%	111 (94%)	7 (6%)	

* Fisher's Exact Test

Table 14: Correlation Saturation on Presentation with Non-invasive Ventilation Support

This study analyzed association between saturation and outcome (admission or discharge), low saturation was associated with need for admission. Hundred percent of patients with saturation ≤ 95% were admitted and only 28% of patients with saturation ≥96% were admitted. (Table 14)

Saturation	Admission		P value
	No (n =85)	Yes (n= 37)	
≤ 95%	0 (0%)	4 (100%)	0.008*
≥ 96%	85 (72%)	33 (28%)	

* Fisher's Exact Test

Table 15: Correlation saturation with admission

This study showed no association between saturation and length of stay (z= -0.347, p = 0.729).

Chapter 6.7.2: Correlation between change in respiratory score within 24 hrs admission and length of stay (Table 15)

Change of score over first 24 hours was not associated with length of stay: Children's Hospital Wisconsin Respiratory Score (r= 0.137, p= 0.418), and Kristjansson Respiratory Score (r=0.157, p=0.352).

	r value	p value
CHWRS	0.137	0.418
Kristjansson	0.157	0.352

Table 16: Changes score first 24 hours with length of stay

Chapter 6.7.3: Inter-rater reliability (Table16)

Both scoring system showed high inter-rater reliability. The intraclass correlation coefficient was 0.918 (95% CI 0.883, 0.940) for Children's Hospital of Wisconsin Respiratory Score and 0.829 (95% CI: 0.755, 0.880) for Kristjansson Respiratory Score. However, the Children's Hospital of Wisconsin Respiratory Score had a higher inter-rater reliability compare to Kristjansson Respiratory Score.

	Intraclass Correlation	95% Confidence Interval Lower Bound	Upper Bound	p value
CHWRS	0.918	0.883	0.943	< 0.001

Table 17: Inter-rater Reliability Children's Hospital Wisconsin Respiratory Score

	Intraclass Correlation	95% Confidence Interval Lower Bound	Upper Bound	p value
Kristjansson	0.829	0.755	0.880	< 0.001

Table 18: Inter-rater Reliability Kristjansson Respiratory Score

Analysing of inter-rater reliability of each component of both scoring system, we noted that breath sound component of each scoring system had the lowest intraclass correlation (CHWRS ICC 0.248, p= 0.060 and KRS ICC 0.449 , p <0.001). Surgical status of Children's Hospital Wisconsin Respiratory Score was not taken into account as there were no patients who were recruited required surgical intervention. The highest inter-rater reliability for Children's Hospital Wisconsin Respiratory Score was Chest X-ray/Lungs sound followed by heart rate, respiratory rate then dyspnea.

The highest inter-rater reliability score for individual component of Kristjansson Scoring System was general condition followed by respiratory rate and recession. (Table 18)

Components	Intraclass Correlation	95% Confidence Interval		p value
		Lower Bound	Upper Bound	
Children's Hospital Wisconsin Respiratory Score				
Breath Sounds	0.248	-0.077	0.475	0.060
Dyspnea	0.808	0.726	0.866	< 0.001
Retractions	0.769	0.670	0.838	< 0.001
Respiratory Rate	0.809	0.727	0.867	< 0.001
Heart Rate	0.892	0.845	0.924	< 0.001
Oxygen Need	0.831	0.759	0.882	< 0.001
Activity Appearance	0.834	0.762	9.884	< 0.001
Cough Ability/Secretions	0.687	0.552	0.781	< 0.001
Chest X-ray/Lung Sound	0.918	0.882	0.942	< 0.001
Surgical Status	-	-	-	-
Kristjansson Scoring System				
Respiratory Rate	0.742	0.629	0.821	< 0.001
Recessions	0.740	0.628	0.819	< 0.001
Breath Sounds	0.449	0.212	0.615	< 0.001
Skin Colour	0.660	0.513	0.763	< 0.001
General Condition	0.749	0.640	0.825	< 0.001

Table 19: Scoring System Components Inter-Rater Reliability

Chapter 6.7.4: Impact of aetiology (viruses and mixed infections) on outcome in children admitted for bronchiolitis (Table 19)

Admission hours (Length of stay) was regrouped into admission hours less and equal to 72 hours and more than 72 hours. This is based on the mean length of admission of 3 days from previous study. (Pelletier et al., 2006) Length of stay was analysed for association with positive NPS culture, number of positive NPS organism and types of NPS organism.

There was no significant association between length of stay and positive NPS culture (p= 0.999).

Positive NPS cultures were further regrouped to 1 positive organism and more than 1 positive organism. There was no significant association between length of stay with number organisms (p= 0.239).

Length of stay was further assessed with NPS positive cultures for virus only, bacterial only and positive culture for both virus and bacterial. Positive NPS culture for both virus and bacteria showed significant correlation with length of stay (p= 0.032).

	Value	df	p value
Positive Virus	0.135	1	0.713
Positive Bacteria	2.530	1	0.112
Positive both virus and bacteria	4.623	1	0.032

Table 20: Correlation NPS with length of stay

Chapter 6.7.5: Comparison of individual components in predicting admission (Table 20)

Significance of each individual component of both scoring systems in predicting admission was also analysed.

Each score was divided with maximum score of each to get a probability score, hence allowing the all scores to be comparable. Using area under receiving operator characteristic curve (aROC) to compare, we compared each component of both scoring system with outcome (discharge/admit).

For Children's Hospital Wisconsin Respiratory Score, the component that was most significantly predicted outcome was dyspnea (aROC 0.769), followed by respiratory rate (aROC 0.739) and retraction (aROC 0.711). Among these 3 components, respiratory rate had the highest sensitivity and dyspnea has the highest specificity. (Table 18)

For Kristjansson Respiratory Score, the component that most significantly predicted outcome was respiratory rate (aROC 0.690), followed by general condition (aROC 0.684) and chest recession (aROC 0.618). Among these 3 components, chest recession had the highest sensitivity and respiratory rate had the highest specificity.

Assessment of breath sounds in both scoring systems showed that if poorly predicted admission with p= 0.493 for Children's Hospital Wisconsin Respiratory Score and p= 0.337 for Kristjansson Respiratory Score. Skin colour component in Kristjansson Respiratory Score also showed poor prediction with admission (p= 0.636).

Component	Area	S. Error	Asymptotic Sig	Asymptotic 95% Confidence Interval		Sensitivity	Specificity
				Lower Bound	Upper Bound		
Children's Hospital Wisconsin Respiratory Score							
Breath Sound	0.539	0.057	0.493	0.427	0.652	0.081	0.976
Dyspnea	0.769	0.045	<0.001	0.680	0.857	0.405	0.953
Retraction	0.711	0.051	<0.001	0.612	0.810	0.378	0.918
Respiratory Rate	0.739	0.050	<0.001	0.641	0.837	0.838	0.506
Heart Rate	0.678	0.052	0.002	0.576	0.781	0.784	0.529
Oxygen Need	0.638	0.059	0.016	0.522	0.754	0.297	0.976
Activity Appearance	0.659	0.056	0.005	0.550	0.769	0.568	0.729
Cough ability/ secretions	0.682	0.053	0.001	0.579	0.785	0.730	0.624
Chest X-ray/ Lung sound	0.696	0.057	0.001	0.585	0.808	0.459	0.929
Surgical Status	-	-	-	-	-	-	-
Kristjansson Scoring System							
Respiratory Rate	0.690	0.053	0.001	0.586	0.794	0.297	0.976
Chest Recession	0.618	0.054	0.038	0.513	0.724	0.838	0.365
Breath Sound	0.555	0.056	0.337	0.444	0.666	0.054	0.999
Skin Colour	0.527	0.058	0.636	0.413	0.641	0.027	0.999
General Condition	0.684	0.056	0.001	0.575	0.793	0.541	0.824

Table 21: Comparison each component in predicting admission

Chapter 7: Discussion

The aim of this study was to determine which of the 2 respiratory scoring systems i.e. Kristjansson Respiratory Score (KRS) or the Children's Hospital of Wisconsin Respiratory Score (CHWRS) was better at assessing respiratory status, hence need for admission, in children admitted with bronchiolitis. While both scoring systems had high discriminative power, the Children's Hospital of Wisconsin Respiratory Score fared better than Kristjansson Respiratory Score, both in its ability to predict admission as well as the inter-rater reliability.

Unfortunately there is no study that reports the median score of the CHWRS and KRS. Feldman A et. al. (Feldman et al., 2015), used the Modified Tal Scoring System to assess patients who presented with acute respiratory illness to Vanderbilt Children's Hospital from year 2004-2008. Six hundred and thirty patients were recruited and median (IQR) respiratory score of infants who were hospitalized [6.5 (4,9)] was higher than those who received outpatient treatment [1 (0,3)]. In this study, both the Children's Hospital of Wisconsin Respiratory Score and the Kristjansson Respiratory Score had significantly higher median scores for patients who required admission versus those requiring outpatient treatment.

Our assessors were combination of medical officers from Pediatric and Accident and Emergency department.

The years of experience (year of start working as houseman) of first assessors in emergency department ranged from 3 to 9 years with a mean of 8.5 years.

Whereas for years of experience for second assessors in emergency department ranged from 3 to 14 years with a mean of 6.5 years.

Ninety-one percent of first assessors had working experience of more than 5 years and 74% of second assessors had working experience of more than 5 years.

We used scores from first assessors for analyzing our objectives and score from both assessors for assessment of inter-rater reliability.

Unfortunately, there is no study who report years of experience of assessors.

An aROC of ≥0.75 is usually taken as being clinically significant (Fan et al., 2006), and in this study, both scoring systems achieved this. However, the Children's Hospital of Wisconsin Respiratory Score (aROC 0.832) had a higher score, indicating that it had a better discriminative power at predicting admission. Sensitivity of predicting admission was 86% for both scores, but the Children's Hospital of Wisconsin Respiratory Score had a higher specificity score of 65% while the KRS was 44.7%. Therefore, the Children's Hospital of Wisconsin Respiratory Score was able to identify severity of illness better than the Kristjansson Respiratory Score. Although the Children's Hospital of Wisconsin Respiratory Score is a more tedious respiratory score, with more than 5 components, hence more difficult to perform, it's higher predictive value, is important when assessing patients, severity of illness, following clinical trends and also in evaluating responses to therapeutic interventions, especially for research purposes.

Looking through all literature and our results, CHWRS is better than the RDAI, KRS and Wang Respiratory Score, but yet to be compared to the Modified Tal Respirtory Score and REsVinet.

In a previous study conducted by Destino, L. et al.(Destino et al., 2012) at the Children's Hospital of Wisconsin, with the aims to establish validity and reliability of 2 respiratory score [Respiratory Distress Assessment Instrument (RDAI) and Children's

Hospital of Wisconsin Respiratory Score (CHWRS)] and also to identify respiratory score component that most determined overall respiratory status, showed that the Children's Hospital of Wisconsin Respiratory Score (aROC 0.68) was more predictive of ED disposition compared to Respiratory Distress Assessment Instrument (aROC 0.51). CHWRS (ICC 0.73 95% CI 0.60-0.82) also had a higher inter-rater reliability compared to the RDAI (ICC 0.39 95% CI 0.17-0.58).

In this study, low saturation had a significant association with hospitalization and severe illness. However, there was no significant association between low saturation and longer duration of hospitaization. This is different from a previous study conducted by Corneli H et al. (Corneli et al., 2012), whose aim was to identify clinical characteristics of bronchiolitis associated with admission and length of stay. This study showed that the initial saturation was associated with need for hospitalization and length of stay. Duration of hospitalization could be affected by other factors e.g. patient's age and immunity, days of illness, treatment received on admission, response of an individual to treatment and organisms causing illness, rather than just only one parameter.

Presence of hypoxia will usually result in hospitalization.(Bush & Thomson, 2007; Chamberlain, Patel, & Pollack, 2005) In a previous study, conducted by Mallory MD et al. (Mallory, Shay, Garrett, & Bordley, 2003) whose aim was to assess the influence of specific differences in oxygen saturation and respiratory rate on admission for patients with bronchiolitis patients surveyed, 519 physicians of members of American Academy of Pediatric Section of Emergency Medicine in United States. Forty-three percent of physicians recommended admission for patients who presented with Spo2 94% and below and respiratory rate ≥50 breaths per minute. In another study conducted by Shaw et al.(Shaw, Bell, & Sherman, 1991), whereby 213 infants with bronchiolitis was

assessed by 6 independent clinical and laboratory variables (including general appearance, oxygen saturation less than 95%, gestational age, respiratory rate more than 70 breaths per minute, chest x-ray findings and age youngers than 3 months old) with severity of illness, found that oxygen saturation less than 95% was the only best predictor of severity of illness.

Length of stay was further analyzed with other parameters. Only patients who have co-infection (NPS culture positive for both virus and bacteria) were associated with longer hospitalization. Change of respiratory score after 24 hours, positive nasopharyngeal secretions culture and number of organism was not associated with length of stay. Coinfections have been associated with severity of illness. In a recent study, Cebey-Lopez et. al (Cebey-Lopez et al., 2016) wanted to correlate co-infection with clinical outcomes in children admitted with acute respiratory illness. This study collected information as part of Spanish Prospective multicenter study (GENDRES network). A total of 204 children were recruited in this study. This study showed that thenumber of detected viruses was not associated with severity of illness but bacterial superinfection was associated with PICU admission, requirement of respiratory support and longer hospital length of stay. This is consistent with our study result.

In a previous study conducted by Destino, L. et al. (Destino et al., 2012), no significant association could be found between Respiratory Distress Assessment Instrument (RDAI) and Children's Hospital of Wisconsin Respiratory Score, with length of stay. Bronchiolitis is a dynamic illness, which requires frequent assessment of child's status.(American Academy of Pediatrics Subcommittee on & Management of, 2006). Severity of illness might be not contributed by a single parameter and might be combination of a few factors.(McCallum, Chatfield, Morris, & Chang, 2016) Hence,

assessment of severity of illness at a single point of time might not be associated with length of stay.

In any test or scoring system, the inter-rater reliability is important to achieve consistent assessment findings among assessors.

Based on intraclass correlation coefficients described by Koo KT et al. (Koo & Li, 2016), ICC of 0.75 to 0.9 is considered as good while an ICC > 0.9 indicates excellent inter-rater reliability. Kristjansson Respiratory Score (ICC 0.829) showed good inter-rater reliability, while the Children's Hospital of Wisconsin Respiratory Score (ICC 0.918) showed excellent inter-rater reliability.

This result is consistent with study conducted by Destino et. al.(Destino et al., 2012) in a study to establish validity and reliability for RDAI and CHWRS which showed that CHWRS had a better inter-rater reliability with ICC 0.73 (95% CI 0.60-0.82) versus RDAI ICC 0.39 (95% CI 0.17-0.58).

As for components in the scoring system, both respiratory scores showed the lowest ICC score for breath sounds. This can be explained by differing clinical experience among different assessors. Other factors could be due to the poor description of breath sound component in the respiratory score, e.g. in CHWRS, breath sound was differentiated by presence of inspiratory and expiratory wheeze for moderate illness and marked wheeze for severe illness, which is difficult to interpret in clinical practice. The KRS described presence of wheeze with or without rhonchi and rale for moderate illness and severe wheeze with or without rhonchi and rale for severe illness which is also very confusing and not clearly defined. The finding in this study is consistent with previous studies conducted by Wang, E. et al. and Spiteri MA et. al. (Spiteri, Cook, & Clarke, 1988; Wang, Milner, Navas, et al., 1992) which showed inter-rater reliability or

agreement for breath sound and skin colour were poor. Wang et. al. (Wang, Milner, Navas, et al., 1992) conducted a study to determine inter observer agreement for clinical score in children less than 2 years old admitted for lower respiratory infections (bronchiolitis or pneumonia). The parameter assessed were respiratory rate, retractions, wheeze and general appearance (Later known as Wang Respiratory Score). A total of 56 patients were recruited, and the lowest inter-observer agreement was for retraction (kappa 0.25) and wheeze (kappa 0.31) and highest observer agreement was for general assessment (kappa 0.48). In another study conducted by Spitero MA et. al.(Spiteri et al., 1988) to determine agreement of respiratory signs. 24 physicians were divided into 6 sets and each set examined 4 patients for respiratory signs. Only 55% agreement noted in between physicians. However, McCallum, G. et al. (McCallum et al., 2013) conducted a study to determine validity and reliability of Tal and modified Tal Scoring scoring system. She recruited 115 children aged less than 2 years old who presented to Royal Darwin Hospital with bronchiolitis were recruited. Wheezing component had the best internal consistency among the components evaluated. This was probably because of the vigorous training and calibration sessions using standard protocol, including video recording training which was done in this study. In the present study, our training involved giving power point presentation and explanation of components of respiratory scores only with no calibration or video recording sections were given.

In this study, another component of the Kristjansson Respiratory Score which had low inter-rater reliability was skin color. This result was similar to study conducted by Chin. Et al. (Chin & Seng, 2004), which compared KRS with Wang Respiratory Score, which also showed a low inter-rater reliability for skin color. The skin color description in Kristjansson Respiration Score was classified into normal, pallor or cyanosis. However, cyanosis can only visualized with the naked eye if the saturation is 80% or less (Martin

& Khalil, 1990; Snider, 1990) and pallor may be affected by a low haemoglobin level, where iron deficiency anemia is common is this age group and hence making it difficult to be a reliable sign.

Heart rate and chest x ray/ lung sound component had the highest inter-rater reliability for Children's Hospital Wisconsin Respiratory Score. This is probably because in x rays in children with acute bronchiolitis is more objective and heart rate taken was from the vital signs documentation, hence it is more consistent. Only heart rate of few patients were repeated if manual heart rate assessed had a huge difference compared to heart rate recorded via oximetry.

On the other hand, components in the Kristjansson Scoring System that had the highest inter-rater reliability were general condition, recession and respiratory rate. This is consistent with a previous study (Chin & Seng, 2004) which found general condition, recession and respiratory rate were the components that had highest inter-rater reliability among components of Kristjansson Respiratory Score.

Therefore, in summary, looking at inter-rate reliability for each component of the respiratory score, it does seem that assessment of wheeze/breath sounds in most studies is inconsistent, and perhaps should be removed from scoring systems as it is not an objective measure of severity of illness. Dependence on more objective measures like vitals or like REsVinet scoring system which does not require assessment of breath sound (rhonchi and crepitations) may be easier to use and produce more consistent results.

In this study, each component of the respiratory score was evaluated for its ability to predict admission. Almost all components of Children's Hospital Wisconsin Respiratory Score (except for breath sounds and surgical status) and respiratory rate, recession and

general condition components of the Kristjansson Respiratory Score were significant associated with need for admission.

Generally, each component of Children's Hospital Wisconsin Respiratory Score had higher aROC values compared to the Kristjasnsson Respiratory Score. The highest aROC value for the Children's Hospital Wisconsin Respiratory Score was dyspnea, followed by respiratory rate and retraction. On the other hand, the highest aROC value for Kristjansson Respiratory Score was respiratory rate.

Although the respiratory rate component of the Kristjansson Respiratory Score had the highest aROC value (aROC 0.690), but the sensitivity was low (sensitivity 30%). This was same for dyspnea and retraction component of Children's Hospital Wisconsin Respiratory Score.

Respiratory rate and heart rate component of Children's Hospital Wisconsin Respiratory Score, chest recession and general condition component of Kristjansson Respiratory Score had the highest sensitivity among the components.

This is contrary with previous study conducted which showed oxygen need the individual component that most correlate with hospital admission. (Destino et al., 2012)

This can be explained as the decision for admission does not depends on a single physical examination finding, but more on the general condition, work of breathing (described as dyspnea in CHWRS) and severity of respiratory distress.

Breath sound, surgical status component of Children's Hospital Wisconsin Respiratory Score and skin color, breath sound component of Kristjansson Respiratory Score showed no correlation with predicting admission.

Considering the aROC value and sensitivity, assessment of respiratory rate in the Children's Hospital Wisconsin Respiratory Score significantly correlated with admission.

In summary, all components of CHWRS except breath sound and surgical status and general condition, respiratory rate and chest recession components of KRS correlated well with need of admission. Whereas, breath sound component of CHWRS, skin colour and breath sound components of KRS correlated poorly with need for admission.

Chapter 8: Limitations

1. This study was conducted in a single institution and there are only a small number of patients recruited. A multicenter study and larger amount of patient is required for confirmation of hypothesis.
2. Training – More training with video section and calibration will improve discrimination power if both the assessments.
3. As this study was conducted in a tertiary center, the significant outcome measures especially admission criteria, might differ from other centers.
4. Different and multiple assessors were involved. There are total of 37 assessors involved in this study. All assessors with different exposures and experiences and training.
5. Nasopharyngeal secretions sample were only taken for patients who were admitted. Impact of positive culture of organism on the need of admission could not be associated in this study.
6. Saturation on presentation was taken as the best saturation obtained on arrival. This might be a bias as the best Spo2 might not represent the average Spo2 etc.

Chapter 9: Recommendations

Recommendations for further upcoming studies:

1. Suggest recruitment of patients from multicenter (including primary care setting) and involve larger number of patients.
2. Specify assessors who are fully committed to the study and provide more training and calibration sessions to improve inter-rater reliability, e.g. nurses.
3. Perform the study, inclusive of peak season of bronchiolitis, hence throughout the year.
4. Perform respiratory scoring pre and post treatment to assess treatments institute in Accident and Emergency Department especially hypertonia saline.
5. Specify timing for inpatient assessment of scoring system (before or after treatment e.g. suction and nebulization).
6. Nasopharyngeal secretion culture and virology taken for all patients who presented with acute bronchiolitis to study the impact of aetiology on admission.
7. Saturation at presentation to be taken for more than 5 minutes, to ensure it is an average and not the best Spo2.
8. Training section- More training section inclusive of video section and calibration for further studies.
9. To compare ResVinet Scale with CHWRS- this study showed breath sound is a component that did not correlate with admission and also had poor inter-reliability. Hence comparing a respiratory score which requires minimal physical examination versus a respiratory score which is mostly based on physical examination.

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Chapter 10: Conclusion

This study showed that while both the Children's Hospital Wisconsin Respiratory Score and Kristjansson Respiratory Score were good at predicting admission and had good-excellent inter-rater reliability, the Children's Hospital Wisconsin Respiratory Score was better at predicting admission and had a higher inter-rater reliability

Saturation at presentation correlated significantly with need for admission, severe illness but not with duration of hospitalization. Chest x-ray and heart rate component of Children's Hospital Wisconsin Respiratory Score and respiratory rate and general condition component of Kristjansson Respiratory Score had good inter-rater reliability. Virus and bacteria coinfection was associated with increased duration of hospitalization. Dyspnea, respiratory rate and retraction component of Children's Hospital Wisconsin Respiratory Score and respiratory rate and general condition of Kristjansson Respiratory Score were sensitive at predicting admission.

Changes in respiratory score not associated with duration of hospitalization.

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Appendices

Appendix A

UNIVERSITY OF MALAYA MEDICAL CENTRE

MEDICAL RESEARCH ETHICS COMMITTEE
(Formerly known as Medical Ethics Committee)
UNIVERSITY OF MALAYA MEDICAL CENTRE
ADDRESS : LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA
TELEPHONE : 03-79493209/ 2251 FAXIMILE : 03-79492030

NAME OF ETHICS COMMITTEE/IRB Medical Research Ethics Committee, University Malaya Medical Centre	**MREC ID NO.** 20161229-C13
ADDRESS : LEMBAH PANTAI, 59100 KUALA LUMPUR, MALAYSIA	
PROTOCOL NO(if applicable) :	
TITLE: Comparison of two espiratory scores in children with bronchiolitis	
PRINCIPAL INVESTIGATOR : Doctor Tan Wee Nee	**SPONSOR**

The following item [✓] have been received and reviewed in connection with the above study to conducted by the above investigator.

[✓]	Application to Conduct Research Project(form)	Ver.No :	Ver.Date : 02-01-2017
[✓]	Study Protocol	Ver.No : 2	Ver.Date : 29-12-2016
[✓]	Patient Information Sheet	Ver.No : 1	Ver.Date : 29-12-2016
[✓]	Consent Form	Ver.No : 1	Ver.Date : 29-12-2016
[ ]	Questionnaire	Ver.No :	Ver.Date :
[✓]	Investigator's CV / GCP (Doctor Tan Wee Nee,ANNA MARIE D/O NATHAN, JESSIE ANNE DE BRUYNE,)	Ver.No :	Ver.Date :
[ ]	Insurance certificate	Ver.No :	Ver.Date :
[✓]	Other documents		
	1) Data collection sheet	Ver.No : 1	Ver.Date : 29-12-2016
	2) Kristjansson scoring	Ver.No : 1	Ver.Date : 29-12-2016
	3) Children Hospital of Wisconsin Respiratory Score	Ver.No : 1	Ver.Date : 29-12-2016
	4) CARIF questionnaire in Malay	Ver.No : 1	Ver.Date : 30-12-2016

and the decision is [✓]

[✓] Approved (Full Board)
[ ] Approved (Expedited)
[ ] Rejected(reasons specified below or in accompanying letter)

Comments:

Revised satisfactorily.

The Investigators are required to:

1) *follow instructions, guidelines and requirements of the Medical Research Ethics Committee.*
2) *report any protocol deviations/violations to Medical Research Ethics Committee.*
3) *provide annual and closure report to the Medical Research Ethics Committee.*
4) *comply with International Conference on Harmonization – Guidelines for Good Clinical Practice (ICH-GCP) and Declaration of Helsinki.*
5) *obtain a permission from the Director of UMMC to start research that involves recruitment of UMMC patient.*
6) *ensure that if the research is sponsored, the usage of consumable items and laboratory tests from UMMC services are not charged to the patient's hospital bills but are borne by research grant.*
7) *note that he/she can appeal to the Chairman of Medical Research Ethics Committee for studies that are rejected.*
8) *note that Medical Research Ethics Committee may audit the approved study.*
9) *ensure that the study does not take precedence over the safety of subjects.*

Date of meeting : 15-02-2017
Date of approval : 10-03-2017

This is a computer generated letter. No signature required.

Appendix B

Data Collection

Data entry	
Date	
Time	
Site	

Name RN number Mykid number Age Race Gender	Attached sticker

	Symptoms	Duration
Presenting complaint	Cough	days
	Rhinorrhea	days
	Fever	days
	Tachypnea/ dyspnea	days
	Less active	days
	Reduce oral intake	days
	Noisy Breathing	Yes/ No
	Others(please specify):	

Treatment received for current illness prior to current consultation	Yes	No
	If Yes: Please specify Date/time/place/ what treatment:	

Ill contact	Yes	No
Environmental tobacco smoke exposure	Yes	No
History of previous admission	Yes	No
	If Yes, Please specify	
Other underlying medical Illness	Yes	No
	If Yes, Please specify	
History of wheezing	Yes	No
	If yes, please specify frequency of wheezing episode	
History of nebulisation	Yes	No
Other medications taken before(including MDI)		

For discharge

Discharge medication and plan (If discharge)	

For admission

Total length of stay	Duration	
Nasopharyngeal secretion	Yes/No	Date taken
Result for NPS		
Requirement of oxygen	Yes/No	
Requirement of NIV	Yes/No	
Requrement of Intubation	Yes/No	
PICU admission	Yes/No	
Treament Received in Ward		

Family history

Mother	Age	
	Occupation	
Father	Age	
	Occupation	
Caretaker/ Babysitter	Yes	No
Number of siblings/Position		
Family history of asthma	Yes	No
	If Yes, identify who:	

Past history

Birth history	Term	Preterm
	SVD/LSCS/ Vacumm assisted/ forcep assisted	
Immunization history		

Vital Signs

Blood Pressure		
Heart rate		
SPo2 on room air	Room air	
	Oxygen therapy	
Respiratory rate		

First Assesssor

Name	
Time/date of of assessment	
Scoring for CHWRS	
Scoring for Kristjansson	
Any treatment given prior to scoring	
Doctor qualification	

Second assessor

Name	
Time/date of of assessment	
Scoring for CHWRS	
Scoring for Kristjansson	
Any treatment given prior to scoring	

Doctor qualification	

If patient admitted:

First Assesssor

Name	
Time date of of assessment	
Scoring for CHWRS	
Scoring for Kristjansson	
Any treatment given prior to scoring	
Doctor qualification	

Second assessor

Name	
Time date of of assessment	
Scoring for CHWRS	
Scoring for Kristjansson	
Any treatment given prior to scoring	
Doctor qualification	