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Healthcare-associated respiratory viral infections among hospitalized children at Caritas Baby Hospital: The impact of the infection control program

Nur Adnan Mithqal Jaber

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Prepared by:

Nur Adnan Mithqal Jaber

B.Sc. in Medical Laboratory Science, Al Quds University/ Palestine

Supervisor: Dr. Musa Hindiyeh

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Thesis Approval

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Prepared by: Nur Adnan Mithqal Jaber

Registration No: 22112784

Supervisor: Dr. Musa Hindiyeh

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The names and signatures of the examining committee members are as follows:

1. Head of the Committee: Dr. Musa Hindiyeh Signature
2. Internal Examiner: Dr. Nuha El Sharif Signature
3. External Examiner: Dr. Ali Sabateen Signature

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Dedication

To the soul of my beloved father, Adnan, who taught me strength and determination to achieve my goals. I wished he could share this moment with me

With deep love, and remembrance

Nur Jaber

Declaration

I certify that this thesis submitted for the degree of Master is the result of my research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed: 

Name: Nur Adnan Mithqal Jaber

Date: 10/01/2024

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List of abbreviations

HA-RVIs	Healthcare-associated respiratory viral infections
HAIs	Healthcare associated infections
HA-VI	Healthcare-associated viral infection
PPE	Personal protecting equipment
RSV	Respiratory syncytial viruses
HPIV	Human Parainfluenza viruses
hMPV	Human metapneumovirus
hAdV	Human adenovirus
CBH	Caritas Baby Hospital
SPSS	Statistic Package for Social Science
ICU	Intensive care unit
COVID-19	Corona-virus disease of 2019
ALRI	Acute lower respiratory tract infection
IPC	Infection Prevention and control
CDC	Center of Disease Control and Prevention
DFA	Direct fluorescent antibody
NPA	Nasopharyngeal aspirate
WHO	World Health Organization
Fio2	Fractional inspired o2
AD	Admission days
SD	Standard deviation
TBP	Transmission-based precautions
LOS	Length of stay

Abstract

Background: Healthcare-associated respiratory viral infections (HA-RVIs) could be an underestimated infection. It is one of the leading causes of morbidity and mortality among hospitalized patients especially in pediatric patients. This study aims to determine the role of HA-RVIs on children under five years old who are admitted to Caritas Baby Hospital (CBH) in Palestine (southern area) and explore the impact of the currently followed infection control program of preventing HA-RVIs at CBH.

Study methodology: A retrospective cohort study design was used. The study was conducted among 11570 registered cases that were tested for the presence of HA-RVIs (possible and definite) for the five different respiratory viruses, including RSV, influenza viruses, human adenoviruses, parainfluenza viruses, and human Metapneumoviruses, during the study period from January 2018 until December 2022 at CBH.

Results: Among 11570 of registered cases, 82 were classified as HA-RVIs. Of these, 50 were definite cases, and 32 were possible cases during the five years. The incidence rate was found to be 1.02/1000 admission days (AD) (definite cases = 0.62/1000AD, possible cases = 0.40/1000 AD), with the highest incidence in the year 2019.

The most commonly identified viruses were RSV, Parainfluenza viruses, and Adenoviruses, with incidence rates of (0.42, 0.20, and 0.19/1000ad respectively). The infant group was the most affected, accounting for 75.6% of all cases. Respiratory symptoms were reported in 98.8% of cases, with fever being the most common symptom at 78%. 61% of cases had one or more underlying comorbidities with an odds ratio of 3.31(95% confidence interval= 1.30 -8.39). For Definite HA-RVIs, odds ratio=1.64 (95% confidence interval= 1.07- 2.52). Also, 37.8% of HA-RVIs required respiratory escalation support, and 8.5% of HA-RVI cases required ICU transfer. The mean length of stay was found to be 18.5 days with definite cases requiring a longer length of stay (23.54) compared to possible HA-RVIs (10.56).

For infection multi-component, the mean of hand hygiene compliance increased from 81% to 86% over the years, and the mean of transmission-based precaution compliance (TBP) ranged from 95.3% in 2018 and decreased to 93.6% in 2022. Environmental cleaning started at 94.5% in 2018, peaked at 97% in 2022, and slightly decreased in

2021 to 88.5%. Hand hygiene compliance was found to be negatively associated with the incidence of HA-RVIs (Spearman correlation coefficient = -0.275, and p-value = 0.012). Meanwhile, environmental cleaning and TBP were positively associated with the incidence of HA-RVIs. The visitor restriction policy was found to be effective in reducing the incidence rate (m=0.92 (SD±0.29), p-value =0.000).

Multiple linear regression revealed an association between hand hygiene compliance and a reduction in the yearly incidence of HA-RVIs (B = -0.047, Beta = -0.392, t = -7.680, $p < 0.05$). Conversely, TBP and environmental cleaning were associated with an increase in yearly incidence (B = 0.031, Beta = 0.260, t = 4.172, $p < 0.05$), (B = 0.079, Beta = 0.719, t = 11.365, $p < 0.05$) respectively. Together, these factors explain about 86% of the variation in yearly incidence(R square=0.858)

Conclusion: This study provides significant insights into the understanding of HA-RVIs within the Palestinian context (southern area) and the impact of infection control measures. Comorbidities were considered a risk factor for developing definite HA-RVIs, and compliance with hand hygiene impacted reducing HA-RVIs. Meanwhile, a safe environment and transmission-based precautions need to be further explored and modified to reduce HA-RVIs.

العدوى المرتبطة بالرعاية الصحية للفيروسات التنفسية بين الاطفال وتأثير برنامج مكافحة العدوى على حدوثها في مستشفى الكاريتاس للاطفال-بيت لحم

إعداد الباحثة: نور عدنان مثقال جابر

المشرف: د. موسى هندية

الملخص

الخلفية: تعتبر العدوى المرتبطة بالرعاية الصحية للفيروسات التنفسية أحد انواع العدوى التي لا تحظى باهتمام كافي مع انها قد تكون من الاسباب الرئيسية للمرض والوفاة في المستشفيات وخصوصا عند الأطفال.

تهدف هذه الدراسة إلى تحديد دور العدوى المرتبطة بالرعاية الصحية للفيروسات التنفسية (HA-RVIs)عند الأطفال دون سن الخامسة الذين يتم إدخالهم إلى مستشفى الكاريتاس للأطفال (CBH) في فلسطين (المنطقة الجنوبية) واستكشاف تأثير برنامج مكافحة العدوى المتبع حاليًا للوقاية من الاصابة ب (HA-RVIs)في هذه المستشفى.

المنهجية: دراسة جماعية بأثر رجعي. أجريت الدراسة على 11570 حالة مسجلة للبحث عن وجود حالات محتملة أومؤكدة ل (HA-RVIs) والتي تشمل فيروس المخلوي التنفسي(RSV) ، فيروس الانفلونزا، فيروس الغذي (أدينوفيروس)، فيروس نظير الأنفلونزا وفيروس البشري المتبدل. من بداية كانون ثاني 2018 حتى كانون أول 2022 في مستشفى الكاريتاس للأطفال.

النتائج: اظهر التحليل انه من أصل 11570 حالة تم فحصها، تم تصنيف 82 حالة على أنها (HA-RVIs)ومن بينها تم تحديد 50 حالة كعدوى مؤكدة و32 حالة كعدوى محتملة خلال السنوات الخمس. كان معدل الإصابة1.02 لكل 1000 يوم دخول للمستشفى (الحالات المؤكدة=0.62/ 1000, الحالات المحتملة=1000/0.4) وشهد عام 2019 اعلى معدل للإصابة بالعدوى. من الفيروسات الاكثر إصابة بالعدوى, فيروس المخلوي التنفسي، فيروس نظير الانفلونزا، وفيروس الغذي حيث بلغ معدل الإصابة (0.42، 0.20, 0.19) لكل يوم دخول للمستشفى على التوالي،وكانت فئة الرضع الأكثر تضررا بنسبة 75.3% من جميع حالات الإصابة. 98.8% من الحالات (HA-RVIs) لديها أعراض تنفسية. 78% من الحالات لديها حمى، و 61% من الحالات لديها مرض أو اكثر من الامراض المصاحبة(نسبة الأرجحية=3.31) والتي كان حدوثها

بنسبة اكبر عند حالات العدوى المؤكدة(نسبة الأرجحية=1.64). 37.8% من الحالات(HA-RVIs) احتاجت الى زيادة الدعم التنفسي. 8.5%من الحالات احتاجت دخول الى وحدة العناية المركزة . معدل الاقامة في المستشفى لحالات العدوى المؤكدة يساوي 23.54 يوما ومعدل الاقامة لحالات العدوى المحتملة يساوى 10.56 يوما أي ان متوسط الاقامة للحالات 18 يوم ونصف.

بالنسبة لبرنامج مكافحة العدوى المعتمد،ارتفع متوسط الالتزام بنظافة الايدي خلال فترة الدراسة من 81% إلى 86%، وكان متوسط الالتزام باحتياطات الاحترازية الاضافية بانتقال العدوى 95.3 % في سنة 2018 وانخفض ل 93.6% سنة 2022، وكان متوسط التنظيف البيئي يساوي94.5 % سنة 2018 وانخفض قليلا إلى 88.5 % في عام 2021 بيمنا ارتفع إلى 97% في عام 2022. ومن هنا تبين أن معدل الالتزام بنظافة الايدي يرتبط سلبيا مع حدوث الاصابة ب(HA-RVIs)حيث كان قيمة (علاقة سبيرمان= -0.275, معامل التحديد= 0.855 مع مستوى دلالة احصائية 0.012). كما تبين ايضا ان تطبيق سياسة فرض قيود دخول للزائرين كانت فاعلة في خفض معدل الاصابة بعدوى (HA-RVIs) بنسبة 0.92 مع مستوى دلالة احصائية.

وقد اظهرت الدراسة عند عمل تحليل الانحدار الخطي المتعدد عن وجود علاقة بين الالتزام بنظافة اليدين وانخفاض معدل الإصابة السنوي بـ(HA-RVIs).اما الالتزام بالاحتياطات الاحترازية الاضافية و التنظيف البيئي قد ارتبط بزيادة معدل الإصابة السنوي بها. حيث تفسر هذه العوامل معا حوالي 86% من التباين في معدل الإصابة السنوي (معامل التحديد=0.858)

الخلاصة: تبين هذه الدراسة رؤية فلسطينية مهمة حول مفهوم العدوى المرتبطة بالرعاية الصحية للفيروسات التنفسية وأثر اجراءات برنامج مكافحة العدوى لتقليل من الاصابة بها في المنطقة الجنوبية في فلسطين. اظهرت الدراسة ان من عوامل الخطر للاصابة بالحالات المؤكدة (HA-RVIs) هي وجود امراض مصاحبة. وكان الالتزام بنظافة الايدي لها أثر في تقليل معدل الاصابة ب (HA-RVIs) . مع الاخذ بعين الاعتبار الحاجة الى تعديل مفهوم البيئة الامنة ومفهوم الاحتياطات الاحترازية الاضافية لتقليل انتقال العدوى (HA-RVIs).

Chapter One :Introduction

1.1 Background

Healthcare-associated respiratory viral infections (HA-RVIs) can be an underestimated infection. HA-RVI is one of the leading causes of morbidity and mortality among hospitalized patients (Petrie et al. 2020). A recent study estimated that every year there are around 18 955 cases of HA-RVIs in the acute care hospitals in the USA (Chow and Mermel 2017). Moreover, the same study reported that during the winter or springs seasons 1 in 6 children under the age of 4 and hospitalized for 1 week or more do develop an HA-RVI (Chow and Mermel 2017). Therefore, increased HA-RVI mortality and morbidity rates will make hospitalizations days longer with higher patient care cost (Taylor et al. 2020).

There is a high risk of getting HA-RVIs, due to the fact that these viruses are transmitted via respiratory droplets in addition to being capable of surviving on surfaces for extended periods leading to indirect contact transmission. This is especially true in pediatric hospitals that have other modes of transmission, such as nature behaviors of children in self-mouth inoculation and presence of asymptomatic inpatient or visitors that acts as a reservoir as well as sharing playrooms and toys between wards in the hospital, all of these factors combine to make preventing these infections more challenging (Hei et al. 2018). Consequently, even with special features of transmission in pediatric hospitals, a recent study indicates that good adherence to an infection control program that is simple and easy to implement may help to lower the incidence rates and to protect inpatients from getting these healthcare-associated infection (Alrumi et al. 2020).

According to (Hanley et al. 2021), there was little information available on pediatric HA-VI, but common human respiratory viruses were the most prevalent. Therefore, it is imperative to understand the incidence rates of HA-RVI and the characteristics of the patients who contract them, as well as the impact of infection control programs on HA-RVIs.

1.2 Research Problem:

Healthcare-associated respiratory viral infections (HA-RVIs) are the most common cause of pediatric healthcare-associated infections (Hei et al. 2018).

Thus, identifying the predominant type and characteristics of HA-RVIs along with the impact of prevention measures over five years in pediatric hospitals in Palestine will be useful to enhance our ability to better understand the causes, distribution, and risk factors of infections that make these pediatric patients vulnerable and the consequences of getting infected. This consequently would provide an opportunity to better understand how infection control measures contribute to prevent the spread of HA-RVIs in the pediatric hospital in Palestine, as well as an opportunity to highlight the necessity of establishing a benchmark for HA-RVIs.

Considering the scarcity of research on this topic in Palestine, this study could serve as a baseline model for future planning for tracking HA-RVIs that will enable better characterization of these infections and more effective infection control measures to mitigate the harmful consequences of HA-RVIs.

1.3 Justification and significance:

Several studies have focused on the epidemiology and risk factors of HA-RVIs. In

Southern California, USA, a retrospective cohort study between the years of 2005-2020 indicated that RSV, Parainfluenza viruses and human metapneumovirus (hMPV) were the most predominant HA-RVIs in pediatric ICU in which all those patients had underling core morbidity which increased the necessity for respiratory support (Feldman et al. 2022). This study indicated the need for further studies to examine the relationship between these viruses and length of stay in hospitals combined with morbidity and financial cost. On the other hand, another retrospective study performed at tertiary care adult and pediatric hospitals over one year showed that there were forty nosocomial viral infections identified and the rhino/enterovirus were the most common viruses identified. Pediatric patients had tenfold higher incidence to acquired HAI than adults (Chow and Mermel 2017). The study concluded that there was an urgent need for more diagnostic testing that can aid in the identification process and target infection control efforts and may encourage the development of effective treatments and vaccines (Chow and Mermel 2017).

Another retrospective study underscored the necessity of having a surveillance system for HA-RVIs to facilitate the presence of benchmarks for comparison for these infections. This study compared two pediatric hospitals during a three-year study period that showed a significant rate of HA-RVIs with similarities of identified viruses where the rhinovirus, followed by Parainfluenza viruses and RSV were the most common ones, but showed a difference in overall total incidence rate, unit-specific incidence rates, and higher rates within the hospital that have less than 50% single rooms. The study concluded that further studies of impact infection control practices in the prevention of these infections are needed (Quach, Shah, and Rubin 2018).

According to several studies, adherence to infection control practices will help in reducing HA-RVIs such as improving hand hygiene compliance as reported by

(Weedon et al. 2013). In this study, the first step to reduce the transmission of hospital acquired RSV and influenza was improving hand hygiene compliance. Moreover, In Singapore, a study found that during COVID-19 the implementation of infection control policies that include wearing suitable personal protecting equipment (PPE), improved patient segregation with respiratory symptoms, and visitors' restriction had a marked effect in containing COVID-19 as well as reducing the incidence rates of HA-RVIs (Wee et al. 2020).

Furthermore, a review study summarized that to reduce the incidence rates HA-RVIs, effective multi-modal infection prevention strategies was needed (Most 2020). The implementation of measures such as the use of appropriate PPE, good hand hygiene compliance, patient cohorts, influenza vaccine for the healthcare workers, and visitor restrictions can yield positive results in reducing incident rates.

Based on the aforementioned studies and the importance of having a database on the characteristics of pediatric HA-RVIs and the impact of infection control in reducing these incidence rates, it will be feasible and important to study this topic in Palestine, since no data has been published about this topic. Consequently, this study will be the first study in Palestine that focuses on respiratory virus infection that acquiring during hospitalization and the impact of infection control program in pediatric hospital.

1.4 Aims of Study:

1. To determine the role of HA-RVIs in children younger than five years old and hospitalized at Caritas Baby Hospital (CBH).

2. To explore the impact of the currently followed infection control program at CBH.

1.5 Study expected outcome

This study will be able to assess the incidence, characteristics, and consequences of getting HA-RVIs, and role of infection control programs in preventing HA-RVIs in hospital setting. This may highlight the importance to establish a surveillance system in every hospital to track these infections and prevent them from spreading. Consequently, this study may be able to give evidence and recommendation for decision-makers to urgent need for establishing a national policy to prevent HA-RVIs.

1.6 Study objectives:

1-To identify the incidence and types of HA-RVIs

2-To determine the association between the demographic characteristic and the occurrence of HA-RVIs

3- To determine the association between patient health status and the occurrence of HA-RVIs.

4-To determine the association between patients' medical outcomes with HA-RVIs

5-To explore the impact of multi-component infection control strategies on the occurrence of HA-RVIs.

1.7 Thesis structure

This thesis will be presented in 6 chapters as follows:

- Chapter one: contains the background of the study, problem statement and study justification, and study aim and objectives.

- Chapter two: includes related data (literature review) of conducted international, regional, and in-country studies and research.
- Chapter three: includes the study conceptual framework.
- Chapter four: includes the study area, study methods, population, sampling, and sample size, ethical considerations will also include data collection, processing, and analysis.
- Chapter five: presents the results.
- Chapter six: includes discussion, limitations, conclusion, and recommendations

Chapter Two: Literature review

2.1 Respiratory viruses

Respiratory viruses are considered to be the most common causative agent of acute respiratory infections (Grunberg, Sno, and Adhin 2021). They can cause upper and lower respiratory tract infections with the lower being considered more fatal (Naz et al. 2019). The most common of these infections' targets children under age 5 which is considered the main cause of their hospitalization and deaths as well as increased financial cost to their families and community (Zhu et al. 2021). Consistently, (Zhang et al. 20AD) emphasized that the vast majority of acute lower respiratory infections (ALRI) in children are contributable to respiratory viral pathogens and ALRI-related deaths account for around 15% of all deaths in children under the age of five.

In children with respiratory viruses, it was more common for them to present with various symptoms such as coughing, shortness of breath, wheezing, flaring, and cyanosis on examination, and a greater need for oxygen therapy. It appears that these clinical differences may serve as helpful clinical identifiers of likely viral diagnosis until more conclusive laboratory testing is available (Khuri-Bulos et al. 2018). Another study mentioned that nearly one third of infants with respiratory viral infections are likely to develop bronchiolitis, pneumonia, and severe respiratory distress if they develop symptoms of the lower respiratory tract (Finianos et al, 2016).

Respiratory viruses have different etiological agents that affect children such as respiratory syncytial viruses (RSV), influenza A & B viruses, human adenovirus (hAdV), Parainfluenza viruses (PIV), and human metapneumovirus (hMPV) which account for 60 percent of acute respiratory infections (Homaira et al. 2016). However, these viruses differ in their involvement depending on demographic patterns, season, location, climate, and nature of the health system (Amer et al. 2015). Also, according to a study conducted in Lebanon over a one-year period aimed to study the etiology of respiratory viruses found that human Rhinovirus, respiratory syncytial virus (RSV), human Bocavirus, hMPV and hAdV are the most prevalent viruses detected (Finianos et al., 2016). Another study mentioned that influenza viruses, RSV, hMPV were the primary cause of winter circulating viruses (Stein et al. 2022). Similarly, a Palestinian study showed that influenza and RSV were the main causes of respiratory tract infections in the West Bank between the study years from 2011 to2016, with RSV more prevalent among children under 5 years old in winter months (Abu Seir et al. 2021).

(Bonveh and Temporiti 2018) declared that RSV is the most common cause of acute lower respiratory infection in children during their first year of life, and it is frequently associated with bronchiolitis and pneumonia. However, RSV is regarded as a major cause of hospitalization, accounting for 50-90% of hospitalized infants with bronchiolitis and pneumonia throughout the winter (Zhang et al. 20AD).

According to a global systematic review, 33 million episodes of RSV-Acute lower respiratory tract infection (RSV-ALRI) resulted in 8 million hospital admissions and 59,600 in-hospital deaths in children under five in 2015. Moreover, it was revealed that RSV-ALRI is responsible for 45 percent of hospital admissions and mortality among infants under the age of six months, placing significant strains on healthcare systems (Shi et al. 2017).

Also, a Jordanian study conducted in 2018 found that in winter months, 95 percent of hospitalized children were diagnosed with respiratory viruses, and RSV and human rhinovirus were the most common ones identified. All viruses had higher rates of infections in infants under the age of 6 months. RSV-positive patients are more likely to need oxygen therapy due to having a more severe form of lower respiratory tract disease (Khuri-Bulos et al. 2018).

The severity and hospitalization associated with RSV have been associated with a variety of risk factors. These include being a male, being preterm, having chronic lung disease, inadequate breastfeeding, attending daycare, living with siblings, and being exposed to smoke (Bradley et al. 2005) (Von Linstow et al. 2008) (Rossi et al. 2007)

Meanwhile, 5-15 percent of all respiratory tract infections were due to human metapneumovirus (hMPV) that affects adults and children, but is considered dangerous to infants between the ages of 6-12 months (Stein et al. 2022). Since hMPV can affect upper and lower respiratory tracts in both adult and children, the severity of this virus varies from mild upper respiratory tract infections to life-threatening bronchitis and pneumonia (Stein et al. 2022). According to (Kıymet et al. 2022) study revealed that hMPV is a significant pathogen associated with lower respiratory tract infection in healthy children. However, premature birth, early age, and underlying chronic diseases are considered the main risk factor associated with the virus's severe form (Panda et al. 2014).

In the same context, the seasonal influenza virus causes 3-7% of hospitalizations in children under 5 years of age (Wang et al. 2020). The two main viral strains that cause infection, a transmissible respiratory illness in humans, are influenza A and influenza B (Naz et al. 2019). According to a recent study, influenza A (H1N1) is more prevalent and aggressive among children under 2 whereas influenza B is more prevalent among children between the age of 3 and 11(Jané et al. 2019). However, the influenza virus is considered a major infectious disease around the world because of its antigenic variability in drifting and shifting, where antigenic shifting occurs only with influenza A virus strains, resulting in the emergence of unidentified strains of influenza (Gentile et al. 2018). Furthermore, the author (Zhang et al. 20AD) asserted that influenza infection is a typical uncomplicated and self-limited illness in healthy children, but it can cause significant complications and deaths. Influenza hospitalizations were significantly higher in children under 5. Infants under 6 months of age have the highest rate of pediatric-related influenza fatalities reported. Also, this study mentioned that among the significant health and social consequences of pediatric influenza virus infections are increased frequency of emergency room visits, hospitalizations, and antibiotic use, patients and their siblings missing school days, and their parents missing work days (Zhang et al. 20AD).

However, the human adenovirus (hAdV) infects all ages but is most commonly found in children between 6 months and 5 years of age. This virus is responsible for 7-8 percent of all viral respiratory diseases among children (Shieh 2022) and approximately 20% of neonates and infants infected with pneumonia (Liu et al. 2023). There are at least 113 identified HAdV types classified into seven subgroups (A-G), with Species C, B, B1, and B2 being the most prevalent HAdV types detected in respiratory samples from pediatric patients with ARTI (Liu et al. 2023)

The HAdV is capable of causing a variety of diseases, including respiratory illnesses such as the common cold, bronchiolitis, and pneumonia as well as gastroenteritis, and conjunctivitis (Waghmode, Jadhav, and Nema 2021). Also, according to a review study conducted in China from 2009 to 2020 declared that from the clinical manifestation of hAdV infection in children, the most common symptoms were cough (76.47%), pneumonia (66.56%), expectoration (56.28%), breathing problems (34.69%), runny nose (29.58%), respiratory failure (11.05%), vomiting (25.00%), and diarrhea (16.87%) (Liu et al. 2023). Another Chinese retrospective study highlighted that children who have pneumonia adenovirus are more likely to die if they are less than one year old, hypoxia, and thrombocytopenic (Xu et al. 2023).

Finally, from the predominant acute respiratory viruses, HPIVs (human parainfluenza viruses) come in four different serotypes, and they can infect infants, young children, and immune-compromised individuals, causing upper and lower respiratory tract infections (Rafeek, Divarathna, and Noordeen 2021). HPIV is the cause of 38-64 percent of croup cases, which causes barking coughs and hoarseness (Han, Suh, and Han 2022).

The most prevalent HPIV strain in children is type 3. This is especially the case among infants under 12 months of age, while HPIV types 1 and 2 affect preschoolers (R. A.M. Rafeek et al. 2021). According to recent study, HPIVs account for between 2% and 17% of hospitalizations related to acute respiratory tract infections, second only to RSV as the cause of hospitalizations in children under 5 years (Rafeek, Divarathna, and Noordeen 2021). As each HPIV serotypes predominated at different times of the year, HPIV-3 dominated most frequently in spring, while HPIV-1, 2, and 4 dominated in autumn (Han, Suh, and Han 2022). A review study mentioned that among the predominant risk factors for contracting HPIV infection are malnutrition, vitamin A insufficiency, lack of breastfeeding, overcrowding, and exposure to smoke or environmental contaminants HPIV infections have a socioeconomic impact on families, health care professionals , and society in general (Rafeek, Divarathna, and Noordeen 2021) .

2.2 Diagnosis of Respiratory viruses

Due to the non-specific clinical presentation of these viruses and potential misdiagnosis as bacterial infections, accurate and rapid diagnostic tests for these causative pathogens will assist in determining the appropriate treatment, implementing rapid infection control strategies, reducing hospitalization costs and days, and minimizing the use of unnecessary antibiotics (Bruning et al. 2017).

The diagnostic tests for respiratory viruses have improved over the last few years, including rapid molecular assays and point-of-care testing, as well as using known conventional methods such as culture and immune-diagnostic methods. However, in immune-diagnostic terms, Direct fluorescent antibody testing (DFA) of nasopharyngeal aspirate(NPA) specimens is deemed to be a fast, reliable method for detecting these viruses with high sensitivity and specificity as demonstrated in RSV (94 and 96%), hMPV (95 and 100%), parainfluenza viruses (88 and 99.7%) and adenovirus (62 and 100%) Influenza viruses(93 and 98%) (Pollock et al. 2009) (Das, Dunbar, and Tang 2018).

DFA testing of NPA is considered a cost-effective diagnostic method that capable to detect clinically related infections, making it suitable for routine surveillance (Sadeghi et al. 2011).The results of an Egyptian study indicate that DFA testing of NPA can be used as a rapid diagnosis method for RSV infections, which can lead to earlier treatment and reduce misuse of antibiotics. (Bahey et al. 2018)

2.3 Transmission of Respiratory Viruses

The transmission of respiratory viruses primarily occur when an infected person releases virus particles into the environment. These particles can be spread either directly by large droplets, fine aerosols, and direct physical contact, or indirectly by contaminated surfaces or fomites. Once these particles come into contact with a susceptible individual, they may cause infection (Leung 2021).

RSV, hMPV, and HPIVs can be transmitted through both direct and indirect contact means. Direct transmission can occur through the secretion of coughs or sneezes with an infected person or physical contact with them. Indirect transmission occurs when an individual touches contaminated surfaces or fomites and then touches their face, allowing the virus to enter their body (RSV Transmission, 2023), (Transmission: How HPIVs Spread | CDC, n.d.), (Human Metapneumoviruses | CDC, n.d.). The adenoviruses, along with the other methods mentioned above, can also be transmitted through the air, like influenza viruses, by coughing or sneezing. Additionally, some strains of adenovirus can even spread through an infected person's stool, such as during diaper changing. While rare, adenovirus can also spread through contaminated water sources like swimming pools (How Adenovirus Spreads | CDC, n.d.), (Key Facts about Influenza (Flu), 2023).

In the same concept, these viruses can spread in hospitals through the same routes either via infected visitors, caregivers, and patients or exposure to contaminated surfaces or contaminated hands of healthcare workers (Chow and Mermel 2017).

As part of pediatric care, close contact like feeding, changing, and playing, as well as parental rooming in and kangaroo care in neonatal wards, poses a risk for transmission and a challenge to prevent nosocomial infections (Munjal 2018)

During times when the community circulation of viruses are high, viral infections are the leading cause of pediatric hospitalization. As pediatric hospitals serve as reservoirs for these viruses, children are more likely to contract these viruses in the hospital. Aside from the natural development process of self-inoculation and lack of immunity to these viruses, the presence of interacting playrooms in hospitals, as well as ill visitors such as parents and siblings, make inpatient children more susceptible to HA-VI (Hanley et al. 2021).

There are several factors that influence the acquisition and spread of these viruses in the community, including socioeconomic factors like crowded living conditions, large families, and malnutrition, as well as cultural and geographical factors (khamis et al,. 2012). Also, the transmission of a pathogen to be successful is affected by several factors that need to be considered. The pathogen's own infectivity, the infected individual's level of contagiousness, the susceptibility of the exposed person, the contact patterns between the two individuals, and the environmental stress during transmission all play critical roles (Leung 2021).

2.4 Respiratory viruses' healthcare associated infection

Healthcare associated infections (HAIs) are an unfortunate reality for many patients. These infections can strike 48 hours after admission and are not related to any preexisting medical conditions. Respiratory infections, urinary tract infections, gastrointestinal infections, surgical site infections, bloodstream infections, skin and soft tissue infections, and other types of infections are all classified as HAIs based on the site of infection (Wen and Lin 2022).

Healthcare-associated respiratory viral infection lacks the presence of a unified definition. So, several studies have used different definitions. For example, (Forkpa et al. 2020) study has identified HA-VRIs in a patient who displayed symptoms either on or after three days of hospitalization. Another study defined HA-VRI as a positive viral result after 48 hours of hospitalization (Spaeder and Fackler 2011) .Furthermore, the (Washam et al. 2018) study defined HA-RVI as the presence of a positive test for children on or after day five of hospitalization without previous test results within the past 30 days.

Meanwhile, another study used definitions based on incubation period of each virus, such as in Chow and Mermel's study, HA-RVIs were classified into two categories: definite and possible. A definite HA-RVIs is defined as a case where the number of days between hospital admission and onset of symptoms exceeds the incubation period for the specific virus. On the other hand, a possible HA-RVIs case was defined as a patient who was admitted without clinical signs or symptoms of a respiratory infection, and in whom the number of days from hospital admission to symptom onset was within the range of the incubation period for the identified virus (Chow and Mermel 2017). Likewise, (Most et al. 2023) study identified HARVI by confirming the presence of microorganisms, the appearance of new symptoms during hospitalization, and ensuring the exposure time exceeded the minimum incubation period for each specific virus. The event is classified as definite if it occurs after the maximum incubation period or as possible if it occurs before the maximum incubation period (Most et al. 2023).

Several studies have been conducted to establish the incidence rate of healthcare-associated respiratory viral infections (HA-RVIs). These studies were aimed at evaluating the efficacy of infection prevention and control programs in reducing these infections, as well as assessing the burden or significance of HA-RVIs on morbidity and mortality for affected patients.

Among these studies, a retrospective study conducted in two children's hospitals in New York aimed to determine the incidence rate of healthcare-associated respiratory viral infections (HA-RVIs) during hospitalization. The study revealed an overall incidence rate of 1.29 per 1000 patient-days of HA-RVIs at two hospitals over a period of three years. These findings provide valuable insights into the rates of HA-RVIs acquisition in hospital settings and can help inform efforts to prevent and control these infections (Quach, Shah, and Rubin 2018).

Likewise, another study conducted in Singapore from February to August 2020 revealed a decline in the cumulative incidence of HA-RVIs from 9.69 to 0.83 cases per 10,000 patient days. This remarkable improvement was attributed to the implementation of a multi-modal Infection Prevention and Control (IPC) program. The results indicate that the program was effective in reducing the incidence of HA-RVI (Wee et al. 2021).

Meanwhile, a retrospective observational study conducted in Australia between July 2012 and April 2019 has indicated a noteworthy escalation in the rate of HA-RVIs. The rate increased from 0.63 to 3.38 per 10,000 bed days. This finding is attributed to the heightened detection of virus notification and the altered epidemiology of the virus in the country (Manchal et al. 2020).

The potential consequences of acquiring infections caused by HA-RVIs can be highly significant, leading to substantial morbidity and mortality rates among affected patients. According to a study conducted by Manchal et al, such infections are often associated with an increased hospital stay, escalation of respiratory support, and the need for intensive care in neonatal patients (Manchal et al. 2020). Similarly, a study published by Taylor et al. (2020) mentioned the negative outcomes of HA-RVIs in neonate patients were prolonged hospital stay, increased respiratory support, and higher financial burden (Taylor et al. 2020). Another study mentioned that patients with healthcare associated viral infections experience increased hospitalization days, additional healthcare needs, mortality, and inappropriate antibiotic use. (Hanley et al. 2021). Also, (Hei et al. 2018) study asserted that patients with healthcare-associated viral infections needed more respiratory support and were admitted to the ICU more frequently, and their discharge was delayed (Hei et al. 2018).

2.5 Prevention of HA-RVIs

Numerous studies have been conducted to evaluate the efficacy of infection prevention and control programs in reducing the burden of the HA-RVIs. So to prevent pediatric HA-VI transmission, a bundle of standard prevention practices had shown significant reductions in HA-VI, as stated in a (Hei et al. 2018) study. The bundle consisted of three pillars to prevent transmission. Firstly, it aimed to reduce transmission by staff by adhering to WHO five-moment hand hygiene practices, wearing appropriate protective gear, transmission-based precautions either contact or droplet precaution, and following a sick leave policy. Second, it is focused on reducing transmission from family and visitors by promoting hand hygiene, educating families, limiting visits, and screening visitors. The third pillar focused on reducing transmission in healthcare environments through the disinfection of shared equipment and adherence to cleanliness guidelines (Hei et al. 2018).

Another study by Mermel in 2019, conducted a multi-modal program over eight years that involved screening patients for signs and symptoms, cough etiquette posters, alcohol-based hand dispensers, masking during respiratory virus season, influenza vaccination of staff, contact and droplet precautions, as well as respiratory screening for visitors. Consequently, the risk of hospital-acquired infections showed a significant decline (Mermel et al. 2019).

Another study by Hillier in 2020 demonstrated that adherence to hand hygiene practices is the most effective way to prevent healthcare-associated infections (Hillier 2020).

According to a (Rubin et al. 2018) study, enhanced isolation precautions interventions in children hospital, such as contact and droplet precautions, significantly reduced nosocomial respiratory virus infections

Also, a (Wee et al. 2021) study declared that the introduction of the Infection Prevention and Control (IPC) bundle that was introduced to contain COVID-19 had a positive side effect of also containing HA-RVIs. These measures encompass the segregation of patients with respiratory symptoms, universal mask-wearing, and the proper adherence to standard precautions. The implementation of these measures has resulted in a parallel reduction of HA-RVIs (Wee et al. 2021).

Chapter Three: Study's Conceptual framework

In accordance with the literature review, the conceptual framework for this study consists of:

- Demographic characteristics of HA-RVIs: age, gender, province and residency area.
- Incidence and type of HA-RVIs (Possible and Definite)
- Patients health status: underlying comorbidities, DFA testing of NPA test upon admission, respiratory symptoms upon testing and fever on day test.
- Patients' medical outcomes: the need of escalation of respiratory support, transfer to ICU, length of stay and mortality.
- Infection control multi-components:

1-Standard Precaution: Hand hygiene, PPE, environmental cleaning, visitor restriction

2-Transmission-Based Precaution: Contact precaution, droplet precaution

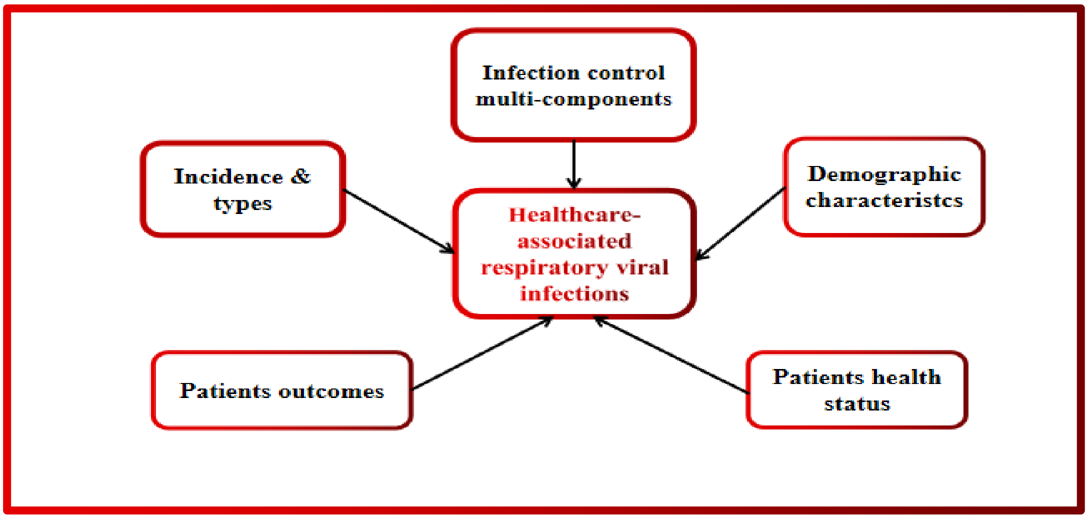

Figure 1: Study Conceptual framework

Healthcare-associated respiratory viral infection: is a type of infection that is defined by the presence of a positive result on a direct florescence assay (DFA) test for any of the five respiratory viruses, including Respiratory syntactical virus, Influenza viruses, Human adenoviruses, Parainfluenza viruses, and human Metapneumoviruses after 48 hours. The infection is considered definite if it occurs after the maximum incubation period or possible if it occurs before the maximum incubation period, provided the exposed time exceeds the minimum incubation period for each specific virus (Table 3.1).

Table 3.1: Incubation period for each virus

Viruses	**Incubation Period(days)**
Respiratory syntactical virus	3-5
Influenza viruses	1-2
Human adenoviruses	3-7
Parainfluenza viruses	3-5
Human Metapneumoviruses	3-5

(Racaniello, 2014)

Respiratory sign and symptom: the presence of evidence of respiratory viral infection such as new onset of fever, sore throat, nasal discharge or stuffiness, cough, hoarseness, retraction, cyanosis and tachypnea. For patients aged <1 year, hypothermia (<37°C), apnea, or bradycardia (Quach, Shah, and Rubin 2018).

Escalation of respiratory support: an increase in respiratory support and classified as one of the following: transitioning from breathing room air to using supplemental oxygen, increasing the fractional inspired (Fi) O2 while using the same non-invasive respiratory support method, switching from non-invasive to invasive respiratory support, or increasing the FiO2 and/or mean airway pressure while using the same invasive method. Non-invasive respiratory support methods include nasal cannula O2, high flow O2, continuous positive airway pressure, or bi-level positive airway pressure. Invasive methods include mechanical ventilation (Saiman et al. 2023).

Incidence of HA-RVI: is determined by calculating the number of HA-RVI cases per 1000 patient admission days, which is obtained by dividing the number of HA-RVIs by the number of hospitalization days and then multiplying by 1000.

Length of stay: the day's number between a patient's admission and release from the hospital

Comorbidity: is a term used to describe the presence of more than one health condition or disorder in an individual. This can include both medical and psychiatric disorders occurring at the same time (Klykylo, 2002) (Arthritis Comorbidities | CDC, n.d.).

Standard precaution: a set of infection prevention measures that is applied to all patient care, regardless of whether or not the patient has an infection (Standard Precautions, n.d.).

Transmission-Based Precautions: an essential part of infection control, providing an extra layer of protection beyond Standard Precautions. They are used when a patient is suspected or confirmed to be infected or colonized with certain infectious agents that require additional precautions to prevent the spread of infection. These precautions are classified into three categories: Contact Precautions, Droplet Precautions, and Airborne Precautions (Transmission-Based Precautions | Basics | Infection Control | CDC", n.d.)

Contact Precautions: a set of measures that are implemented to prevent and control the spread of infectious agents. These agents can be transmitted through direct or indirect contact with the patient or their surroundings, including equipment used for patient care. Cross-infections are commonly transmitted this way (England, n.d.).

Droplet precautions: a set of measures employed to prevent and control the spread of infectious agents over short distances, typically at least one meter. These measures are designed to mitigate the transmission of a person's respiratory tract droplets to another person's mucous or conjunctiva (England, n.d.).

Chapter Four: Methodology

4.1 Setting

This study was conducted at the Caritas Baby Hospital (CBH) in Bethlehem. CBH is the only pediatric hospital in the west bank that provides medical and social services to all children in need. Most of the patients come from the southern parts of the West Bank (60% Bethlehem, 40% Hebron). CBH has three main inpatient wards: the intensive care ward, the neonatal ward, and the pediatric ward (A and B).

4.2 Sample frame

All inpatients under the age of five who are tested for any of five viral respiratory infections (Respiratory syncytial virus, Influenza viruses, Human adenovirus, parainfluenza viruses, human Metapneumovirus) based on laboratory confirmation using direct fluorescent antibodies (DFA) assay method in nasopharyngeal aspirate specimens from January-2018 until the end of the December-2022

4.3 Study design

Retrospective cohort study from January 2018 till the December 2022

4.4 Sampling Method

During the study period From January 2018 until December 2022, all nasopharyngeal aspirate samples tested for the presence of the five different respiratory viruses using DFA assay of NPA specimens will be evaluated for the presence of Definite HA-RVIs and Possible HA-RVIs .

4.5 Exclusion Criteria:

The patient tests were excluded if

- Tests done for the patients over the age of five.
- Tests done for patients who were seen in the outpatient clinics.
- Any duplicate test with same HA-RVIs for the same virus during the test period
- Tests done before 48 hours

4.6 Sample size:

All DFA tests of NPA specimens that done in CBH hospital during the study period from January 2018 till the December 2022 that equal 11570 tests.

4.7 Study tool:

The study tool will be divided into five sections

1- Section one: Incidence and viruses' types of HA-RVI that will include the five respiratory viruses (Respiratory syncytial virus, Influenza viruses, Human adenovirus, Parainfluenza viruses, and human Metapneumovirus)

2- Section two: Demographic characteristics that will include

- Age group: divided into three groups (Neonate group from birth till 28 days, infant group between 29 days to less than 2 years, children group from 2years to less than five years) (Pediatric Medical Devices, 2023).
- Gender: male and female
- Residency area: Camp, village, city
- Province: Bethlehem, Hebron, Jerusalem, others (any others province in Palestine)

3- Section three: patient health status that will include

- The presence of underlying comorbidities and classification of comorbidities based on the type of disorder. These may include genetic disorders, endocrine disorders, respiratory disorders, neonatal disorders, cardiological disorders, neurological disorders, gastrointestinal disorders, vascular disorders, immunological disorders, infectious diseases, growth and developmental disorders, genitourinary disorders, and metabolic disorders.
- DFA testing of NPA specimen upon admission
- Respiratory symptoms upon testing
- Presence of fever on day test.

4- Section four: Patients medical outcomes that include

- The need of respiratory escalation support
- Transfer to ICU
- Length of stay
- Mortality

5- Section five: infection control measures that include observations and data collection indicators/checklists from hospital infection prevention control committee that include:

- Monthly Hand hygiene indicator based on WHO five moment of hand hygiene compliance
- Transmission Based precautions compliance involves wearing the appropriate personal protective equipment such as gown, gloves, goggles, face shield, and mask, proper waste disposal, availability of alcohol rub and hand washing facilities, and the correct use of precaution signs. For instance, droplet precautions are

necessary for influenza viruses and human adenovirus, while contact precautions are required for RSV, Parainfluenza viruses, and human Metapneumovirus.

- Monthly environmental cleaning checklist for maintaining a safe and healthy environment in healthcare facilities by insuring the routine and terminal cleaning
- Visitor policy that restricts the entrance of visitors to the inpatient department since the beginning of COVID-19 in March /2020.

4.8 Data collection

Participants electronic medical records and DFA tests result was extracted from two health information systems, Avicenna and Apex, with the years 2018, 2019 retrieved from Avicenna system, and 2020, 2021, 2022 retrieved from Apex system, and then exported to the Microsoft Excel Program and reviewed by the researcher of this study, and then reviewed again by the supervisor of this study (Dr. Musa Hindiyeh). Electronic medical records provided the following data: age, gender, province and residency area, test results, admission and discharged dates, pediatric wards, tests date, needs for ICU transfer, needs of respiratory escalation support, respiratory symptoms, comorbidities and mortality.

The data of infection control measures was collected from hospital infection prevention control committee that presented indicators in the monthly IPCC meeting minutes

All the data was reviewed twice, first by the researcher and second by the supervisor Dr. Musa Hindiyeh.

4.9 Statistical analysis

Data entry and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS version 25.0). To describe categorical variables, we used frequencies and percentages while continuous variables were described using mean and standard deviations. To measure the association between study variables, the chi-square test, odds ratio accompanied by (95%) Confidence Intervals and Spearman association coefficient were utilized. To compare means between two independent groups for continuous variables, the independent t-test was employed. Multiple linear regression used to assess the strength of the relationship. A significance level of less than 0.05 was deemed statistically significant across all tests.

4.10 Ethical consideration

The study was approved by the Faculty of Public Health Ethical committee of Al-Quds University after submitting the research proposal for discussion (Appendix 1).The permission to do this study was obtained from the Caritas Baby Hospital Medical Research Committee (Appendix 2). In addition, a confidentiality policy was signed at CBH.

Chapter Five: Result

During the study period from January 2018 until December 2022, a total of 13382 tests were performed, with 1812 tests being excluded from the study. The exclusions comprised 1133 tests performed on outpatients and 679 tests performed on patients above five years of age. The remaining 11570 tests were studied, and it was found that 3870 tests were positive for respiratory viruses

Out of the 3,870 positive tests, a total of 82 cases with 84 viruses were identified as healthcare-associated respiratory viruses (HA-RVIs) based on the operational definition of HA-RVI and exclusion criteria applied.

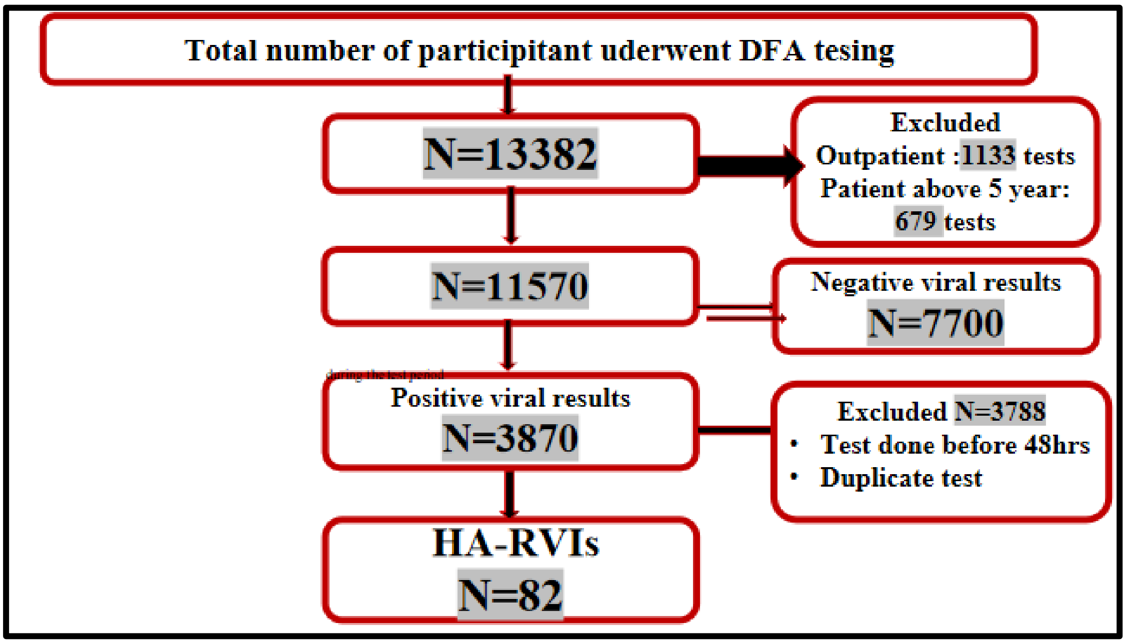

Figure 2: Study flowchart for number of tests involved in the study

5.1 Respiratory Viruses

5.1.1 Basic characteristics for total study population

In our study, we analyzed a total of 11570 tests during five years period to determine the basic characteristics of the study sample. These characteristics included age, gender, province, residency area, inpatient residence, and test year. Then we found the number of positive result and percent for all these basic characteristics.

Table 5.1 provides an overview of the basic characteristics of the study samples. Out of 11570 test results, 33.4% were positive for respiratory viruses, totaling 3,870 tests. It is noteworthy that the majority of the positive viral results came from males with 62%. The results further indicate that 82.8% of the positive cases were recorded among infants, while 49% of the positive viral results were recorded in village areas and 43.3% in city area. The distribution of positive viral results in province showed that 56.1% were recorded in Hebron, 36.7% were recorded in Bethlehem, and 7.2% were recorded in others (Jerusalem, Jenin, Jericho, Ramallah, Tubas, Tulkarem, Qalqilah, Nablus and Gaza). In terms of hospital wards, Pediatric wards A and B had the highest percentage of positive results with 45.1% and 36.6%, respectively. The Neonate ward had a Positivity rate of 15.9%, while the ICU ward had the lowest rate of 2.4%. The yearly percentage of positive results distribution was as follows: 24.1% in the year 2018, 21.1% in the year 2019, 19.2% in the year 2021, and 22.6% in the year 2022. The year 2020 had the lowest percentage of positive results at 12.8%. Regarding the duration of stay, the average length of stay was 4.017 for patients with positive DFA tests, while it was 3.95 for those with negative DFA tests

Table 5.1: Basic characteristics for total study population

		Count	Positive result	%
Total study sample		**11570**	**3870**	**33.40%**
Gender	Female	4406	1471	38%
	Male	7164	2399	62%
Age-Group	Children	1371	276	7.1%
	Infant	8885	3206	82.8%
	Neonate	1314	388	10%
Province	Others	850	277	7.2%
	Bethlehem	4697	1420	36.7%
	Hebron	6023	2173	56.1%
Residency area	Camp	970	294	7.5%
	City	5079	1679	43.3%
	Village	5521	1897	49%
Hospital wards	ICU Ward	364	92	2.4%
	Neonate Ward	1753	615	15.9%
	Pediatrics Ward A	4844	1745	45.1%
	Pediatrics Ward B	4609	1418	36.6%
Year	2018	2613	946	24.4%

	2019	2395	814	21.1%
	2020	1392	480	12.4%
	2021	2163	742	19.2%
	2022	3007	888	22.6%
Length of stay	Positive DFA test	mean(±SD)	4.017(±4.140)	
	Negative DFA test	mean(±SD)	3.95(±5.003)	

5.1.2 Incidence rate of Respiratory Viruses

During the five-year study period, there were a total of 80008 days of hospitalization for all patients. Out of these, 3870 cases tested positive for respiratory viruses, which means that the total incidence rate of respiratory viruses was 48.4 per 1000 admission days. According to Table 5.2, out of the 3870 positive results, the majority of them (2811 cases) were due to RSV, with an incidence rate of 35.2 per 1000 admission days. This makes RSV the most predominant virus found in children under five years. Influenza viruses followed with an incidence rate of 4.2 per 1000 admission days, hMPV with 3.9%, Adenovirus with 3.1 per 1000 admission days, and lastly, Parainfluenza viruses with 2.2 per 1000 admission days.

Table 5.2: Incidence of Respiratory Viral Infections

	Admission days	**Positive cases**	**Incidence**
Total	**80008**	**3870**	**48.4**

Type of virus	RSV	80,008	2813	35.2
	hMPV		311	3.9
	Adenovirus		247	3.1
	Influenza viruses		340	4.2
	Parainfluenza viruses		199	2.5

5.2 Incidence of healthcare-associated Respiratory Viral infections (HA-RVIs)

5.2.1 Incidence of HA-RVIs types

A total of 11570 tests were conducted for the five respiratory viruses. Out of these, 82 tests were identified as HA-RVIs cases. Of these 82 cases with 84 viruses, 50 were classified as Definite HA-RVIs, while 32 were classified as Possible HA-RVIs. The total admission days (AD) were 80,008 days so the total incidence of 82 cases was 1.02 per 1000 AD. The incidence for definite HA-RVIs was 0.62 per 1000 AD, while the incidence for possible HA-RVIs was 0.40 per 1000 AD (Table 5.3).

Table 5.3: Incidence of HA-RVIs

	Admission days	**HA-RVI cases**	**Incidence** per **1000 AD**
Total HA-RVIs	**80,008**	**82**	**1.02**
Definite HA-RVIs		50	0.62
Possible HA-RVIs		32	0.40

5.2.2 Incidence of HA-RVIs per year

The data presented in Table 5.4 displays the distribution of HA-RVI cases and incidence per 1000 admission days on a yearly basis. The highest number of HA-RVI cases (24) with incidence (1.6 per 1000 AD) was recorded in the year 2019, followed by 2022 with 20 cases with an incidence of 1.2 per 1000 AD. In the year 2018, there were 18 cases with an incidence of 1.1 per 1000 AD, and in 2021, there were 13 cases with an incidence of 0.7 per 1000 AD. The year 2020 had the lowest number of HA-RVI cases (7) with an incidence of 0.5 per 1000 AD.

Table 5.4: Incidence of HA-RVIs per year

Year	Admission days(AD)	HA-RVI cases	Incidence/1000AD
2018	16,298	18	**1.1**
2019	15,216	24	**1.6**
2020	13,342	7	**0.5**
2021	17,913	13	**0.7**
2022	17239	20	**1.2**

5.2.3 Incidence of HA-RVIs per virus type

The data presented in Table 5.5 shows the distribution and incidence of the five different types of viruses during the study period. The most commonly occurring virus was RSV, with 34 cases and an incidence rate of 0.42 per 1000 AD. This was followed by Parainfluenza, with 16 cases and an incidence rate of 0.20 per 1000 AD, and then parainfluenza again, with 15 cases and an incidence rate of 0.19 per 1000 AD. Influenza viruses had 13 cases and an incidence rate of 0.16 per 1000 AD, while the least common virus was hMPV, with only 6 cases and an incidence rate of 0.07 per 1000AD

Table 5.5 Incidence of HA-RVIs per virus type

Type of viruses	Admission day	Count	Incidence/1000AD
RSV	80,008	34	0.42
hMPV		6	0.07
Adenovirus		15	0.19
Parainfluenza		16	0.20
Influenza viruses		13	0.16

5.2.4 Incidence of HA-RVIs per hospital ward

The data presented in Table 5.6 shows the distribution of HA-RVI cases and incidence across four different hospital wards. The highest number of cases was observed in pediatric ward A, with 46 cases and an incidence rate of 1.73 per 1000 AD. Pediatric ward B saw 23 cases with an incidence rate of 1.17 per 1000 AD. The lowest number of cases were reported in the ICU ward with 6 cases and an incidence rate of 0.47 per 1000 AD, and Neonate ward with 7 cases and an incidence rate of 0.33 per 1000 AD

Table 5.6: Incidence of HA-RVIs per hospital ward

Hospital Ward	Admission day(AD)	HA-RVI cases	Incidence/1000AD
ICU ward	12,724	6	0.47
Neonate ward	20,950	7	0.33
Pediatric A ward	26,598	46	1.73
Pediatric B ward	19736	23	1.17

5.2.5 Comparisons between Types of HA-RVI's and Incidence of HA-RVI's

Table 5.7 presents a summary of the comparison between the types of HA-RVIs (Possible and definite) and the incidence per 1000 admission days, based on an independent T-test. The table shows that the average incidence per year among Definite HA-RVIs is 0.73 ± 0.27, 0.88 ± 0.30 for incidence per hospital ward, and 0.17±0.07 for incidence per virus type. On the other hand, the average incidence per year among Possible HA-RVIs is 0.55 ± 0.19, 0.49 ±0.18 for incidence per hospital ward, and 0.13± 0.06 for incidence per virus type. Furthermore, the table indicates significant differences between the means of Definite and Possible HA-RVIs in terms of incidence per year (T-test= -3.326, P-value= 0.001), incidence per hospital ward (T-test= -6.736, P-value= 0.000), and incidence per virus type (T-test= -2.523, P-value= 0.014)

Table 5.7: Comparisons between Type of HA-RVI and Incidence of HA-RVI's

Incidence/1000 AD	**Type of HA-RVI**	**N**	**Mean (±SD)**	**T-Test**	**P-value**
Incidence per year	Possible	32	0.55 (±0.19)	-3.326	**0.001**
	Definite	50	0.73 (±0.27)		
Incidence per hospital ward	Possible	32	0.49 (±0.18)	-6.736	**0.000**
	Definite	50	0.88 (±0.30)		
Incidence per virus type	Possible	32	0.13 (±0.06)	-2.523	**0.014**
	Definite	50	0.17(±0.07)		

5.3 Demographic characteristics

5.3.1 HA-RVIs distribution by demographic characteristics

Table 5.8 displays the percentage breakdown of Hospital Acquired Respiratory Viral Infections (HA-RVIs) by age group, gender, province, and residency area. The data reveals that infants accounted for the highest percentage of HA-RVIs at 75.6%, followed by children at 18.3%, and neonates at 6.1%. Males reported a higher percentage of HA-RVIs at 70.7%, while females accounted for 29.3%. In terms of province, Hebron had the highest number of cases with 51.2%, followed by Bethlehem at 43.9% while the remaining 3.7% cases came from other areas (two cases from Gaza, one case from Jenin and one case from Jerusalem). The residency area distribution was as follows: 59.8% from the villages, 35.4% from the cities, and 4.9% from the camps.

Table 5.8: HA-RVIs distribution by demographic characteristics

Demographic characteristics		**Count**	**Percent %**
Age-Group	Children	15	18.30%
	Infant	62	75.60%
	Neonate	5	6.10%
Gender	Female	24	29.30%
	Male	58	70.70%
Province	others	4	4.9%
	Bethlehem	36	43.90%
	Hebron	42	51.20%
Residency area	Camp	4	4.90%
	City	29	35.40%
	Village	49	59.80%

5.3.2: Comparisons between Demographic characteristics and Types of HA-RVIs.

Table 5.9 presents data on the different types of HA-RVIs (definite and possible) and their distribution across various demographic characteristics. The data shows that village areas had the highest percentage of both definite (58%) and possible (62.5%) cases, followed by city areas with 38% for definite and 31.3% for possible cases. The lowest percentage was found in camp areas, with only 4% definite and 6.3% possible cases. In terms of province, Hebron had the highest percentage of both definite (50%) and possible (53%) cases, followed by Bethlehem with equal percentages of 44% in both categories. For Jerusalem, only possible cases were reported (3%), while Gaza and Jenin had 6% for definite cases. When it comes to age-group distribution, the infant group had the highest percentage among both definite (72%) and possible (81%) cases, while the children came in second with definite (22%) and possible (13%) cases. The Neonate group was the lowest with equal percentages for both (6%). In terms of gender, males were predominant in both categories, with 70% for definite and 72% for possible cases, while females came in second with 30% for definite and 28% for possible cases. It's important to note that there is no significant association between the two categories (definite and possible) in demographic characteristics.

Table 5.9: Comparisons between Demographic characteristics and Types of HA-RVIs

		Type of HA-RVIs				**P value**
		Definite		**Possible**		
		Count	**Percent %**	**Count**	**Percent %**	
Residency area	**Camp**	2	4.0%	2	6.3%	.771
	City	19	38.0%	10	31.3%	
	Village	29	58.0%	20	62.5%	
Province	**Others**	3	6%	1	3%	.318

	Bethlehem	22	44%	14	44%	
	Hebron	25	50%	17	53%	
Age-Group	**Children**	11	22%	4	123%	.318
	Infant	36	72%	26	81%	
	Neonate	3	6%	2	6%	
Gender	**Female**	15	30.0%	9	28%	.856
	Male	35	70.0%	23	72%	

5.3.3 Association Between each age-group, gender and types of virus

A Pearson chi-square test was conducted to examine the relationship between age-group, gender, and five different viruses. The results, as shown in Table 5.10, indicate that RSV virus and influenza viruses have a statistically significant relationship with age group, with chi-square values of 6.3 and 13.39, and p values of 0.042 and 0.001, respectively. However, there is no significant Association between the other viruses and age-group. Furthermore, gender does not appear to have any significant relationship with the types of viruses (p value > 0.05).

Table 5.10: Association between each age-group, gender and types of virus

Pearson Chi-Square Tests						
		RSV	**hMPV**	**Adenovirus**	**Parainfluenza**	**Influenza viruses**
Age-Group	Chi-square	6.319	2.088	1.836	1.702	13.391

	P value	**.042**	.352	.399	.427	**.001**
Gender	Chi-square	.267	.052	.060	.651	1.438
	P value	.605	.820	.806	.420	.230

5.4 Patient health status

5.4.1 HA-RVIs distribution by patient health status

The following data is presented in Table 5.11, which shows the percentage of patients' health status with respect to underlying comorbidities, respiratory symptoms, and fever on the day of the test, and DFA testing of NPA specimen results upon admission. The data, 61% of HA-RVIs have underlying comorbidities, while 39% of HA-RVIs do not have any underlying comorbidities. The data also reveals that 84.1% of HA-RVI patients tested negative for DFA test of NPA specimen upon admission. When it comes to symptoms upon testing, the data shows that 98.8% of HA-RVI patients had respiratory symptoms, and 78% of patients had fever on the day of the test.

Table 5.11: HA-RVIs distribution by patient health status

Patient health status		**Frequency**	**Percent %**
Underling Comorbidities*	No	32	39.0%
	Yes	50	61.0%
	Negative	69	84.1%

DFA testing of NPA specimens upon admission	Not done	13	15.9%
Respiratory symptoms upon testing	No	1	1.2%
	Yes	81	98.8%
Fever	No	18	22.0%
	Yes	64	78.0%

Underling Comorbidities: see Figure 3

Figure 3 provides the percentage of comorbidities categorized by disorders. The most common comorbidity was neonatal disorder, accounting for 15.9% of cases, followed by neurological disorder (13.4%), respiratory disorder (8.5%), genetic disorder (6.1%), endocrine disorder (4.9%), and cardio-logical disorder (4.9%). The least common comorbidities were gastrointestinal, immunological, vascular, and genitourinary disorders, each accounting for only 1.2% of cases. Infectious disease and metabolic disorder accounted for 2.4% of cases each, while growth and development disorders accounted for 3.7%.

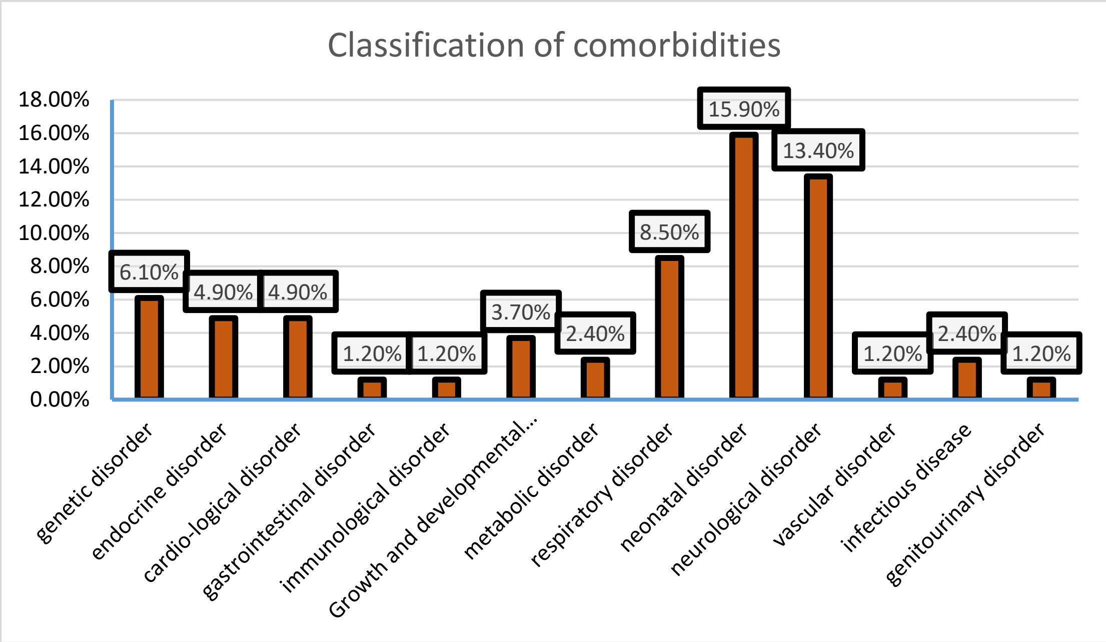

Figure 3: **Classification of comorbidities**

5.4.2 Comparisons between Types of HA-RVI and patient medical health status

Table 5.12 provides a summary of the patient's health condition in two types of HA-RVIs. The summary includes the results of the DFA testing conducted upon admission, presence of fever on the day of testing, respiratory symptoms experienced upon testing, and underlying comorbidities. The data shows that 86% of patients with definite HA-RVIs underwent the DFA testing of NPA tests upon admission, and the results were negative. Similarly, 81.3% of patients with possible HA-RVIs also had negative DFA test results. Regarding fever, 76% of definite cases experienced it on the day of testing, and a slightly higher proportion, 81.3%, of possible cases also exhibited fever. Additionally, 72% of definite cases had underlying conditions, while 43.8% of possible cases had comorbidities. The table underscores a significant relationship between the types of HA-RVI (possible and definite) and the presence of underlying comorbidities (P value = 0.011), whereas other aspects of patient medical health status exhibit no statistically significant Association. In the term of presence of respiratory symptoms, there was only one case with no respiratory symptoms from 82 cases, so it hard to perform a statistical analysis.

Table 5.12: Comparisons between Types of HA-RVI and patient medical health status

Patient medical health status		**Types of HA-RVIs**				**P value**
		Definite		**Possible**		
		Count	**Row N %**	**Count**	**Row N %**	
DFA testing of NPA specimens upon admission	Negative	43	86%	26	81.3%	.566
	Not done	7	14%	6	18.7%	
Presence of fever	No	12	24%	6	18.7%	0.575
	Yes	38	76%	26	81.3%	
Presence of Comorbidities	No	14	28%	18	56.2%	**.011**
	Yes	36	72.0%	14	43.8%	

However, when calculate the odds ratio for comorbidities in relation to types of HA-RVIs. The analysis revealed an odds ratio of 3.31 for comorbidities, with a 95% confidence interval ranging from 1.302 to 8.397. For definite HA-RVIs, the odds ratio was found to be 1.64, with a 95% confidence interval of 1.07 to 2.52. However, for possible HA-RVIs, the odds ratio was 0.49, with a 95% confidence interval of 0.29 to 0.85.

5.5 Patient medical outcome

5.5.1 HA-RVIs distribution by patient medical outcome

Table 5.13 shows the impact of getting specific viruses during the study period. This impact is measured by the need for respiratory escalation support, transfer to ICU, length of stay, and death. According to the data, during the study period, 37.8% of HA-RVI cases required escalation of respiratory support, while 8.5% of cases needed to be transferred to the ICU. Unfortunately, two HA-RVI cases (2.4%) resulted in death. The data also indicates that the average length of stay was 18.5 days, ranging from 2.7 days to 127.9 days.

Table 5.13: HA-RVIs distribution by Patient medical outcome

Variables		Count	Percentage%
The need for respiratory escalation support	No	51	62.20%
	yes	31	37.80%
Transfer to ICU	No	75	91.50%
	yes	7	8.50%
Mortality	No	80	97.60%
	yes	2	2.40%
Length of Stay	mean(±SD)	18.5(±22.6)	
	min-max	2.7-127.9	

5.5.2 Comparison of length of stay between patients with HA-RVIs and those with not-HA-RVIs (positive for viruses).

Table 5.14 displays the difference in length of stay between patients who had respiratory viruses from the community (not-HA-RVIs) and those who acquired these viruses during their hospital stay (HA-RVIs). The data shows that patients with HA-RVIs had a longer mean length of stay (18.51) compared to those with not-HA-RVIs (mean=3.94). This data strongly suggests that the presence of HA-RVI is significantly linked to a longer hospital stay. The low p-value (0.000) further supports the statistical significance of this association. In summary, the table provides evidence that the occurrence of HA-RVI is associated with a considerable extension in the length of hospital stays.

Table 5.14: Comparison of length of stay between patients with HA-RVIs and non-HA-RVIs

	HA-RVI (Y-N)	**N**	**Mean**	**SD**	**P-value**
Length of Stay	No	3498	3.94	5.28	**0.0000**
	Yes	80	18.51	22.6	

5.5.3 Comparison between HA-RVI types and Patient outcomes

The following tables provide a summary of the relationship between the different types of HA-RVIs (Possible and Definite) and the resulting outcomes such as the need for respiratory escalation, transfer to ICU, death (as shown in Table 5.15), and length of stay (as shown in Table 5.16)

Table 5.15 indicates that the outcomes of both definite and possible HA-RVIs were similar in terms of the need of respiratory escalation support (38%, 37.5%), transfer to ICU (8%, 9.4%), and death (2%, 3.1%), respectively. These findings suggest that there is no statistically significant association between the type of HA-RVIs and these different outcomes, based on the chi-square test (P value > 0.005).

Table 5.15: Comparison between HA-RVI types and Patient medical outcomes

		Type of HA-RVIs				**P-Value**
		Definite		**Possible**		
		Count	**Percent %**	**Count**	**Percent %**	
The need for respiratory escalation support	No	31	62.0%	20	62.5%	**.964**
	yes	19	38.0%	12	37.5%	
Transfer to ICU	No	46	92.0%	29	90.6%	**.828**
	yes	4	8.0%	3	9.4%	
Mortality	No	49	98.0%	31	96.9%	**.747**
	yes	1	2.0%	1	3.1%	

In contrast, Table 5.16 specifically addresses the length of stay for the two types of HA-RVIs (Possible and Definite). The mean length of stay for patients with "Definite" HA-RVIs (23.54 days) is significantly longer than for those with "Possible" HA-RVIs

(10.56 days). The data reveals a statistically significant difference between the two groups, with a t-value of 2.59 and a p-value of 0.011, based on an independent t-test. The 95% confidence interval for the difference in means is 3.01 to 22.97 days. This indicates a notable distinction in the duration of hospitalization, emphasizing the impact of the type of HA-RVI on the length of stay.

Table 5.16: Comparison between HA-RVI types and length of stay

	Type of HAI	**N**	**Mean**	**SD**	**Independent t test**	**p-value**	**95% Confidence Interval**	
							Lower	**Upper**
Length of Stay	Possible	31	10.56	17.93	2.59	**<u>0.011</u>**	3.01	22.97
	Definite	49	23.54	23.97				

5.5.4 Association between Patients outcomes and Types of viruses

Table 5.17 displays the association between five different respiratory viruses and various patient outcomes. The data indicates that patients who were infected with RSV and Parainfluenza viruses required more respiratory support compared to other viruses, as evidenced by significant association (P values of 0.017 and 0.020, respectively) based on Pearson Chi-Square tests. However, there was no association between any of the viruses and ICU transfer or death. Furthermore, the data revealed a significant negative association (P value of 0.009) between RSV and length of stay, indicating that patients with RSV tend to have shorter hospital stays compared to those with other viruses.

Table 5.17: Association between Patients medical outcomes and Types of viruses

Patients outcomes	**Test Type/ P value**	**RSV**	**hMPV**	**hAdV**	**HPIV**	**Influenza virus**
The need for respiratory escalation support	Pearson Chi-Square	5.660	.409	.156	5.414	1.425
	P-Value	<u>**.017**</u>	.522	.693	<u>**.020**</u>	.233
Transfer to ICU	Pearson Chi-Square	2.831	.604	.541	1.855	1.442
	P-Value	.092	.437	.462	.173	.230
Mortality	Pearson Chi-Square	.062	.162	.459	.497	1.792
	P-Value	.804	.687	.498	.481	.181
Length of stay	t-test independent	-2.700-	.866	.479	479	1.067
	P-Value	<u>**.009**</u>	.389	.633	.389	.123

5.5.5 The relationship between age-group and gender and the need for respiratory escalation support, transfer to ICU.

The following table 5.18 presents a summary of patient outcomes (need for respiratory escalation support, transfer to ICU) in relation to age group and gender. The data indicates that no child required transfer to the ICU while 8.1% of the infant group and 40% of the neonate group needed ICU transfer. Both males and females had a similar percentage (8.6% and 8.3% respectively) of ICU transfer. However, statistical analysis showed a significant association between being a child and not requiring transfer to the ICU (P-value=0.021). But for infants, neonates, males and females, there was no statistically significant association between these variables and the need for ICU transfer. Regarding the need for respiratory escalation, the data showed that 20% of the children group, 38.7% of the infant group, and 80% of the neonate group required respiratory escalation. Of these, 41.7% were male and 36.2% were female. The chi-square test for Age Group indicated a marginally significant association (p-value = 0.054) between age group and the need for respiratory escalation. This suggests that there may be some association between age group and the need for respiratory support, but it does not reach conventional levels of statistical significance. On the other hand, the chi-square test for Gender showed no statistically significant association between Gender and the need for respiratory escalation (P-value>0.05).

Table 5.18: The relationship between age-group and gender and the need for respiratory escalation support, transfer to ICU

		Transfer to ICU				P value	The need for respiratory escalation support				P value
		No		yes			No		Yes		
		Count	%	Count	%		Count	%	Count	%	
Age-Group	**Children**	15	100%	0	0.00%	**.021**	12	80%	3	20.0%	**.054**
	Infant	57	91.9%	5	8.10%		38	61.3%	24	38.7%	
	Neonate	3	60%	2	40.0%		1	20.0%	4	80.0%	
Gender	**Female**	22	91.7%	2	8.3%	.966	14	58.3%	10	41.7%	.856
	Male	53	91.4%	5	8.6%		37	63.8%	21	36.2%	

5.5.6: The relationship between each of gender, age group, and length of stay:

Table 5.19 displays data on the length of stay in relation to gender and age group. The mean length of stay for males was 19.37 and for females, it was 16.51. In terms of age group, the neonate group had the highest mean length of stay at 29.72, followed by the infant group at 19.52, and the children group had the lowest mean length of stay at 10.12. The p-value of 0.653 indicates there is no statistically significant difference in the length of stay between genders. However, there is a marginally significant difference in the length of stay among different age groups, with a p-value of 0.087. It is important to note that the significance level is relatively high, and to draw more definitive conclusions, additional statistical tests or a larger sample size may be necessary.

Table 5.19: The relationship between each of gender, age group, and length of stay

Variable		**Length of Stay**		
		Mean	**SD**	**P value**
Age-Group	Children	10.12	8.96	**0.087**
	Infant	19.52	23.92	
	Neonate	29.72	29.09	
Gender	Female	16.51	19.57	0.653
	Male	19.37	23.92	

5.6 Infection control multi- component

5.6.1 Descriptive analysis for infection control indicators

The compliance rates of healthcare workers with infection control measures are presented in Tables 5.22 and 5.23. These measures include Hand Hygiene, environmental cleaning, and transmission-based precautions (TBP). The compliance rates are shown by year and by ward.

Table 5.20 presents the compliance rates over the course of five years. It shows that the highest Hand Hygiene compliance recorded in 2022, with an average of 86%. The compliance rate was 84.8% in 2021 and 82.3% in 2020. However, the lowest compliance rates were observed in 2019 (80.5%) and 2018 (81.5%).The range (min-max) varied over the years, with the lowest recorded compliance in 2020 (77%) and the highest in 2022 (88%).

In terms of TBP compliance rates, the averages were as follows: 2018 (95.3%), 2019 (95.8%), 2020 (90.3%), 2021 (87.5%), and 2022 (93.7%). The range (min-max) fluctuated each year, with the lowest compliance in 2021 (84%) and the highest in 2018 and 2019 (both at 97%).

For environmental cleaning compliance rates, the highest average rate was noted in 2022 (97%), 2019 (95.5%), and 2018 (94.4%). However, the compliance rate was lowest in 2021 (88.5%) and 2020 (89.3%). The range (min-max) remained relatively narrow, indicating a consistently high level of compliance.

Table 5.20: Compliance with infection control indicators for the five years

Year		**Hand Hygiene compliance**	**Environmental cleaning compliance**	**Transmission-Based Precautions compliance**
2018	Mean (min - max)	81.5%(78-84)	94.5%(93-97)	95.3%(93-97)
2019		80.5%(79-82)	95.5%(95-97)	95.8%(94-97)
2020		82.3%(77-86)	89.3%(87-93)	90.3(88-93)
2021		84.8%(83-89)	88.5%(88-89)	87.5(84-89)
2022		86.0%(83-88)	97%(96-97)	93.6(93-95)

Table 5.21 displays the compliance rates observed in four different hospital wards during the study period. It shows that the Neonate ward had the highest hand hygiene compliance rate at 85%, followed closely by the ICU ward at 84%, and then the Pediatric A ward at 83%. The lowest compliance rate was observed in the Pediatric B ward at 80%. All four wards had a high compliance rate in terms of environmental cleaning indicators, with nearly similar results across the five years. The ICU ward had an average compliance rate of 94.2%, while the neonatal ward had a compliance rate of 93.2%. The Pediatric A and B wards had compliance rates of 92%. In terms of compliance to transmission-based precautions, all four hospital wards had the same high percentage. Pediatric A had 93.8%, Pediatric B had 92.5%, the neonate ward had 92%, and ICU ward had 91.6%

Table 5.21: Compliance with infection control indicators for different hospital wards

Ward		**Hand Hygiene compliance**	**Environmental cleaning compliance**	**Transmission Based Precautions compliance**
ICU ward	Mean (min -max)	84% (81-88)	94.2% (88-97)	91.6 (90-97)
Neonate ward		85% (82-89)	93.2% (89-97)	92 (88-96)
Pediatric A ward		83% (80-87)	92.0% (88-97)	93.8 (89-96)
Pediatric B ward		80% (77-83)	92.0% (87-97)	92.5 (88-97)

5.6.2 Association between different infection control compliance and incidence of HA-RVIs

A Spearman correlation adopted to find the association between different infection control compliance (hand hygiene compliance, environmental cleaning compliance and transmission-based precaution compliance (TBP compliance) and the yearly incidence of HA-RVIs.

In terms of hand hygiene compliance, the table 5.22 shows the association between hand hygiene compliance and incidence per year by using Spearman correlation. It very interesting, the data shows when comparing hand hygiene compliance and the yearly incidence, a moderate negative association of -0.275 that was statistically significant with a p-value of 0.012, implying that higher hand hygiene compliance is associated with lower yearly incidence rates. This finding underscores the impact of hand hygiene practices in reducing the overall yearly incidence rates.

Table 5.22: The association between hand hygiene compliance with yearly incidence of HA-RVIs

Spearman correlation		
Variables	**Correlation Coefficient**	**P value**
• **Hand Hygiene compliance** • **Incidence HA-RVIs per year**	-.275-	**0.012**

In contrast, when comparing the environmental cleaning and TBP compliance the data reveals a positive association of (r=0.332 and r= 0.684) respectively that was statistically significant (p-value= 0.002 and p-value=0.001). The findings underscore the importance of further exploration is needed to understand the underlying factors contributing to this association between environmental cleaning and TBP measures and the occurrence of HA-RVIs.

5.6.3 Comparison between yearly incidence before and after visitor restriction

Table 5.23 shows the comparison of the yearly incidence before and after the implementation of the visitor restriction policy. The years 2018 and 2019 represent the period before the visitor restriction policy was implemented (pre-policy years), while the years 2020, 2021, and 2022 represent the period after the policy was implemented (post-policy years). The data indicates that the average yearly incidence during the pre-policy years was 1.39, which is higher compared to the post-policy years' average of 0.92. This reduction is highly statistically significant, with a P-value of 0.000. This indicates that the visitor restriction policy had a significant impact on reducing the yearly incidence.

Table 5.23: Comparison between yearly incidence before and after visitor restriction

	Category	N	Mean	SD	P-value
Yearly incidence	Pre-policy	42	1.3876	.24822	**.000**
	Post-policy	40	.9150	.29660	

5.6.4 Multiple linear regression between the incidence of HA-RVIs and infection control measures:

An analysis of multiple linear regression was conducted to explore the relationship between the incidence of HA-RVIs and infection control measures, including hand hygiene, environmental cleaning, and transmission-based precautions. The R square value of 0.858 indicates that 85% of the variability in yearly incidence can be attributed by these factor.

The results from Table 5.24 reveal a positive association between transmission-based precautions and yearly incidence (B = 0.031, Beta = 0.260, t = 4.172, $p < 0.05$), indicating a statistically significant and moderately positive effect. Similarly, increased environmental cleaning is strongly associated with a significant and positive relationship (B = 0.079, Beta = 0.719, t = 11.365, $p < 0.05$), suggesting that higher compliance with environmental cleaning is linked to an increase in yearly HA-RVI incidence. In contrast, higher hand hygiene compliance is associated with a significant and moderately negative relationship (B = -0.047, Beta = -0.392, t = -7.680, $p < 0.05$), implying that increased hand hygiene compliance is linked to a decrease in the yearly incidence of HA-RVIs.

Table 5.24: Regression Coefficients for yearly incidence

Yearly incidence					
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
Transmission based precautions	0.031	0.007	0.26	4.172	0.000
Hand hygiene	-.047-	0.006	-.392-	-7.680-	0.000
Environmental cleaning	0.079	0.007	0.719	11.365	0.000

Chapter Six: Discussion, conclusion and recommendations

6.1 Introduction:

Between January 2018 and December 2022, a total of 11570 tests were conducted using the DFA method on NPA samples to detect the presence of five respiratory viruses for inpatient under the age of five years. Results indicated that 33.4% of the tests (3870 samples) tested positive for the presence of the viruses. These findings are in line with a retrospective study conducted in Palestine which observed that 28.7% of patients with acute respiratory tract infections tested positive for different etiological agents out of 15413 tested samples (Abu Seir et al. 2021).

The data reveals that the percentage of positive results was higher in males, at 62%, and infants were found to have the highest Positivity rate, at 82.8%. Hebron emerged as the location with the highest percentage of Positivity, at 56.1%. In terms of hospital wards, pediatric wards A and B had the highest percentage of positive results, at 45.1% and 36.6%, respectively. The year 2018 recorded the highest percentage of Positivity, at 24.4%, while 2020 recorded the lowest percentage, at 12.4%, which could be attributed to the lockdown imposed at the onset of COVID-19. The overall incidence of respiratory viral infection was 48.4%, with RSV being the most prevalent virus, with an incidence rate of 35.2. This observation aligns with a previous Jordanian study, which also identified RSV(34%) as the most frequent cause of hospitalization due to respiratory infection (Awad et al. 2020).

6.2 Incidence of HA-RVIs and virus types

During this retrospective cohort study, out of 11570 tests conducted, 3,870 had positive results. Of these, 82 cases were identified as HA-RVIs with 84 distinct viruses. Among these cases, 50 were defined as definite HA-RVIs, while 32 were categorized as possible HA-RVIs. The study observed an overall incidence rate of 1.02 per 1000 admission days for HA-RVIs, with 0.62 and 0.40 for definite and possible HA-RVIs, respectively. Interestingly, these findings are consistent with a study conducted in Texas, which reported an incidence rate of 0.98 per 1000 patient days for HA-RVIs, with 0.63 and 0.35 for definite and possible HA-RVIs, respectively (Most et al., 2023). Similarly, a study conducted in New York reported an overall incidence rate of 1.29 per 1000 patient days in two hospitals (Quach, Shah, and Rubin 2018)

The most common etiology of HA-RVIs is RSV, then followed by parainfluenza viruses and Adenoviruses. This is consistent with the findings of a study conducted in Southern California by (Feldman et al.2022), indicating that RSV, Parainfluenza viruses, and hMPV are the most common HA-RVIs in ICU units. Additionally, (Most et al. 2023) study identified RSV as the most common virus after Rhinovirus, while a study conducted by (Yamaguto et al. 2022) found that Rhinovirus, RSV, and Parainfluenza viruses were the most common viruses over a seven years in Southern Brazil. Furthermore, an Australian study indicating that RSV, hMPV were the most HA-RVIs viruses in children <18 (Manchal et al. 2020).

According to the data on yearly incidence, the highest incidence rates were observed in 2018 and 2019, with rates of 1.1 and 1.6, respectively. After that, there was a decline in 2020, with incidence rates dropping to 0.5. This decline is attributed to the lockdown measures that were implemented during the COVID-19 pandemic, along with universal masking. However, despite the partial lifting of the lockdown measures and the continued universal masking, the incidence rates silently increased to 0.7 in 2021. By 2022, the incidence rate had risen to 1.2 with the lockdown measures were lifted, and mask-wearing was no longer mandatory. This may indicate that the COVID-19 years had a positive impact on the following years. This was noticed in a study conducted in Singapore where the incidence rate declined to (0.83 from 9.69) cases per 10,000 patient-day during the seven months in the year 2020 after the IPC strategies for containment of COVID-19 in the hospital were implemented (Wee et al. 2021).

Regarding the distribution of incidence in hospital wards, it seems that the Neonate and ICU wards had the lowest percentage of incidence of HA-RVIs, at 0.33 and 0.47 respectively when compared with the other hospital wards. This could be attributed to the fact that there were restrictions on visitations in these wards and it was observed a low viral incidence in total study population, which helped to curb the spread of the viruses. This trend is in line with the findings of a previous study, which revealed that neonatal ICU had the lowest incidence rate compared to other departments, for nearly similar reasons (Quach, Shah, and Rubin 2018).

In our comparison of the incidence of ,HA-RVIs between Possible and Definite types we analyzed three categories: incidence per hospital ward, per virus type, and yearly incidence. We found that the Definite HA-RVIs had a statistically significant higher mean in all three categories compared to the Possible HA-RVIs with a P value of less than 0.05. This suggests that the "Definite" type generally exhibits a higher incidence of HA-RVIs than the "Possible" type. These findings highlight the importance of distinguishing between these types to develop effective intervention strategies.

6.3 Demographic characteristics

According to the data, infants have the highest percentage of HA-RVIs at 75.6%. This may be due to the fact that most admitted patients belong to the infant group, compared .to neonates and children However, when compared to a previous studies, the age group stratification differs from our study such as (Most et al. in 2021) study found that patients under the age of 2 had a percentage of 48%, while those between the ages of 2 and 5 had a percentage of 18%, and patients above the age of 5 had a percentage of 34%. Another study mentioned that 49.1% of patient had HAI caused by respiratory viruses was between the age group 0-2 years and most patient was from pediatric ones with 76.4 percentage with median age 2.8 years (Yamaguto et al. 2022).

Additionally, males are more susceptible to HA-RVIs than females, with a percentage of70% that nearly similar to (Yamaguto et al. 2022) study with 60% for males. Hebron recorded the highest percentage of cases related to HA-RVIs at 51.2%, followed closely by Bethlehem with 43.9%. The majority of reported cases were concentrated ,in villages, accounting for 59.8%, while cases in cities constituted 35.4%. Notably CBH hospital, theonly ,pediatric hospital in the northern region of the West Bank played a crucial role in treating patients, with a significant number originating from Hebron and Bethlehem. However, there was no significant statistical difference between demographic characteristics and the types of HA-RVIs (Possible and Definite). Nonetheless, a significant statistical difference emerged between RSV and Influenza viruses in the age group, with a p-value less than 0.05, while other viruses and gender exhibited no significance. The study suggests that age has a significant .impact on the occurrence of RSV and Influenza viruses

6.4 Patient health status

Based on the data provided, 84.1% of patients with HA-RVIs exhibited negative results for viruses in DFA test of NPA specimen upon admission. However, subsequent testing, conducted after 48 hours, yielded positive results, indicating the possibility that patients were in the incubation stage during hospital admission or may have contracted the viruses while in the hospital. To address such variations in infection acquisition, the study adopts two distinct definitions of HA-RVIs - Possible and Definite. A previous study declared that negative results for respiratory viruses were common, prior to HA-RVI occurred (Most et al., 2023).

The data further indicates that 98.8% of HA-RVI patients exhibited various respiratory symptoms that were recorded in their medical files. While an absence of respiratory symptoms was reported in one case, fever was the most frequently reported symptom, noted in 78% of cases. This finding is consistent with a study conducted in the United States, which established that 83% of pediatric patients with HA-RVIs exhibited fever (Chow and Mermel, 2017). Moreover, the data suggests that 61% of HA-RVI cases had one or more underlying comorbidities, with neonatal, respiratory, genetic, endocrine, and cardiological disorders being the most commonly reported comorbidities. These findings align with those of a study revealing that 63.9% of patients with healthcare-associated RSV infections had different comorbidities, with respiratory, neonatal, neurological, cardiovascular, and gastrointestinal disorders being the most prevalent (Saiman et al. 2023).

The data analysis revealed a significant association between two types of hospital-acquired respiratory viral infections (HA-RVIs), Possible and Definite, and comorbidities. The odds of experiencing HA-RVIs are 3.306 times higher for individuals with comorbidities, which is statistically significant. The 95% confidence interval showed a reasonable confident that the odds ratio falls between 1.302 and 8.397. For Definite HA-RVIs, the data revealed that individuals with comorbidities have 1.64 times higher odds of experiencing Definite HA-RVIs than those without comorbidities. The 95% confidence interval showed a reasonable confident that the odds ratio falls between 1.07 and 2.52. On the other hand, for Possible HA-RVIs, the data revealed that individuals with comorbidities had 0.49 times the odds of experiencing Possible HA-RVIs than those without comorbidities. The 95% confidence interval indicated the association may not be statistically significant falls between 0.29 and 0.85.

These results suggest that the presence of comorbidities is associated with an increased risk of overall HA-RVIs and Definite HA-RVIs, but a decreased risk of Possible HA-RVIs. Thus, comorbidities are consider a risk factor for the development of Definite HA-RVIs.

In terms of other variables of patient health status and the types of HA-RVIs the analysis did not reveal any statistically significant association between them.

6.5 Patient medical outcome:

6.5.1 Need of respiratory escalation support:

Based on our data, 37.8% of HA-RVI cases require respiratory escalation support. This is consistent with a study conducted by (Feldman et al.2022), which concluded that one-third of patients require respiratory escalation, and another study by (Mph et al. 2023), which found that 29% of adult patients with healthcare-associated RSV need respiratory escalation support. Moreover, statistical significance has been observed between RSV and Parainfluenza viruses and the need for respiratory escalation support, with these viruses requiring more respiratory support than others. In contrast an Australian study did not find any difference in the need for mechanical ventilation based on the type of virus (Manchal et al. 2020). This difference in results could be due to the fact that our study measured the need for respiratory escalation as all invasive and non-invasive oxygen supports.

Additionally, the data reveals a potential association between age group and the need for respiratory escalation support, with marginal statistical significance (p-value 0.054), indicating a higher percentage of infants and neonates requiring such support. This in constant with a previous study that focused on the association between healthcare-associated RSV and the escalation of respiratory support. The earlier study found that infants aged 12 months or younger required more respiratory support escalation than those who did not require such escalation (Saiman et al. 2023). Notably, no significant differences were observed based on gender or types of HA-RVIs. Also (Saiman et al. 2023) study found no association between gender and healthcare-associated-RVS.

6.5.2 Need for ICU transfer:

The data analysis indicates that out of the total cases involving Hospital-Acquired Respiratory Viral Infections (HA-RVI), 8.5% required transfer to the Intensive Care Unit (ICU). This percentage is consistent with the findings reported by (Hei et al. 2018) in Pennsylvania, where 11% of the cases required ICU transfer. (Chow and Mermel. 2017) reported a higher percentage of 12% of 40 nosocomial respiratory viral cases admitted to the ICU. The data analysis also revealed that there is no statistically significant association between the need for ICU transfer and the types of HA-RVIs or gender, which is consistent with the findings of (Manchal et al. 2020) study. However, a statistically significant association was found between the need for ICU transfer and the age group, where children showed a significant association with not requiring ICU transfer. Nonetheless, it is important to note that different studies have assessed the need for ICU transfer based on different age groups. For instance, (Manchal et al. 2020) study declared that patients under the age of 18 years had a significant association with the need for ICU and endotracheal intubation.

The data indicates that 8.5% of HA-RVI cases needed ICU transfer. This in constant with (Hei et al. 2018) study conducted in Pennsylvania indicates 11% of cases needs transfer to ICU, while (Chow and Mermel 2017) study had higher percentage (12% of forty nosocomial respiratory viral) admitted to ICU. Moreover, the data emphasized that there is no statistically association between ICU transfer and types of HA-RVIs or gender neither no association between need to ICU transfer and the types of viruses this is in constant with (Manchal et al. 2020) study findings. Meanwhile, a statistically significant association found between need of ICU transfer and age group that indicates a children show a significant association with not requiring ICU transfer. However, different studies assessed the need of ICU transfer based on different age group that consider the adults in these group such as (Manchal et al. 2020) study that declare that patient under the age 18 years had a significant associated with the need on ICU and endotracheal intubation.

6.5.3 Mortality

The data reveals two unfortunate deaths, constituting 2.4% of the total cases, with distinct factors contributing to the complexity of each patient's situation. The revision of their medical files showed that in the first case, associated with possible HA-RVIs and RSV, the patient tested negative for DFA upon admission, had neurological comorbidities, necessitated noninvasive respiratory escalation, and was deceased 45 days from the day test. The second case, linked to definite HA-RVIs and Influenza, also tested negative for DFA upon admission but had an infectious disease and vascular disorder. This patient required mechanical ventilation from admission day, with no additional need for respiratory escalation, progressing to multiple organ failure and requiring peritoneal dialysis, ultimately passing away 54 days from the day test. This may suggest that no matter what virus is involved in these cases, various health conditions and various medical interventions can influence their outcome. Notably, there is no statistically significant association between the types of HA-RVIs and death, nor between the types of viruses and death. Nevertheless, several studies have reported a higher percentage of fatalities. For instance, (Chow and Mermel. 2017) observed 13% of patients with HA-RVI who passed away during their hospital stay. Another study by (Yamaguto et al. 2022) reported that 4.7% of patients with HA-RVI died, and all of them had preexisting comorbidities.

6.5.4 Length of stay

The average length of stay was 18.5 days, with a range of 2.7 to 127.9 days. This is similar to a study conducted by (Torres-Garcia et al.2019), which emphasized that patients with healthcare-associated viral pneumonia had a median length of stay of 14 days. However, other studies have reported longer lengths of stay. For example, (Most et al. 2021) found that the median length of stay for HA-RVI was 30 days, while (Yamaguto et al. 2022) reported a median length of stay of 45 days.

The comparison of mean Length of Stay (LOS) between patients acquiring respiratory viruses during their hospital stay (HA-RVIs) and those with pre-existing respiratory viruses (non-HA-RVIs) revealed a statistically significant association. The LOS for HA-RVIs (mean=18.5) was significantly longer compared to non-HA-RVIs (mean=3.94), indicating a notable association between the occurrence of HA-RVIs and extended hospital stays. This finding aligns with a study by (Mph et al. 2023) that identified a significant association (p-value < 0.001) between healthcare-associated RSV and longer hospitalization (median=10 days), compared to community-onset RSV (median=6 days). The study concluded that healthcare-associated RSV was significantly linked to a longer hospital stay. In a similar context, a case-control study conducted in the United Kingdom by (Zinna et al. 2016) found a significant association (p-value < 0.001) between neonates with nosocomial viral respiratory infections and an increased length of stay (mean=76 days) compared to control subjects (mean=41 days), emphasizing the tendency for prolonged hospitalization in cases of nosocomial viral respiratory infections.

Upon comparing the duration of hospitalization with the necessity for respiratory escalation support and ICU transfer, the data reveal a statistically significant association between these factors. This suggests that patients requiring respiratory escalation and ICU transfer have a longer duration of hospitalization. This finding is consistent with the study by (Saiman et al. 2023), which also determined a statistically significant association between the requirement for respiratory escalation support and the duration of hospitalization (P <0.001). Specifically, the study found that the duration of hospitalization was greater among patients with healthcare-associated RSV infection requiring respiratory escalation support (median = 32 days) compared to those without this requirement (median = 8 days) (Saiman et al., 2023).

However, a significant relationship is observed between different HA-RVI types, with Definite HA-RVIs showing a considerably higher mean length of stay (23.54 days) compared to possible HA-RVIs (10.56 days). This association, evidenced by a p-value of 0.011. Notably, no existing studies were identified to support this specific association.

Additionally, the data indicates a significant negative association between RSV infection and length of stay, suggesting that cases with RSV tend to experience shorter hospital stays compared to those with other viral infections. Interestingly, no prior studies were found that specifically investigated this association, emphasizing the novel nature of this observation.

Furthermore, the analysis delves into the relationship of age group and gender on the length of hospital stays. Children exhibit the lowest mean length of stay (10.12 days) in comparison to infants and neonates (19.52 days and 29.72 days, respectively). While the p-value of 0.087 suggests a borderline significant difference among age groups, no significant distinction is noted between genders, with males having a mean length of stay of 19.73 days and females 16.51 days.

In the context of age groups, a previous study revealed a statistically significant association between patients' age and their length of stay. The study demonstrated that patients aged over 65 years had a significantly longer mean length of stay of 78.3 days, compared to those under 18 years who had a mean length of stay of 35.8 days (Manchal et al. 2020). Notably, no prior studies were identified that specifically explored the relationship between length of stay and various pediatric age groups.

6.6 Infection control multi- component

The implementation of a comprehensive infection control multi-component program at Caritas Baby Hospital (CBH) stands out as a commendable initiative aimed at ensuring the safety of both patients and healthcare workers. The Infection Prevention and Control (IPC) program in CBH, in particular, focuses on reducing healthcare-associated infections through the adoption of standard precautions during patient interactions, regardless of the patient's condition. Furthermore, transmission-based precautions are emphasized when dealing with patients exhibiting respiratory symptoms, which further minimizes the risk of healthcare-associated infections. This confirm with previous study that reveals the adoption of specific preventive measures has led to a marked decline in pediatric HAVI (Hei et al. 2018). Similarly, a study declared that introduced an Infection Prevention and Control (IPC) program, encompassing essential measures such as hand hygiene, surveillance, contact precautions, patient isolation, and environmental cleaning. This comprehensive approach has demonstrated significant efficacy in preventing Healthcare-Associated Infections (Ershova et al. 2018).

To ensure the impact of the IPC program, healthcare workers are required to adhere to monthly indicators that measure compliance with hand hygiene, environmental cleaning, and transmission-based precautions (TBP).

6.6.1 Hand Hygiene compliance

The data on hand hygiene compliance at CBH provides insight into the adherence of healthcare workers to recommended hand hygiene practices. The yearly hand hygiene compliance from 2018 to 2022 shows a positive trend, with the mean increasing from 81.5% to 86.0%, indicating an improvement in healthcare workers' commitment to proper hand hygiene. The mean hand hygiene compliance across all wards is relatively high, ranging from 80% to 84%, suggesting a positive overall trend. The ranges in each ward fall within acceptable limits, indicating a consistent commitment to hand hygiene practices.

The analysis of the association between hand hygiene compliance and the yearly incidence of hospital-acquired respiratory viral infections (HA-RVIs) indicates a statistically significant negative association= -0.275, p-value=0.012. This finding suggests that a higher degree of hand hygiene compliance is associated with a reduction in the incidence of HA-RVIs over time. This result come in constant with (Weedon et al. 2013) study that noted a discernible increase in the average hand hygiene compliance rate during the study period (2005 to2009). This increase was noted to have escalated from 82.7% to 95.9%. Concomitantly, there was a marked reduction in the transmission ratios of both RSV and influenza. The Spearman association coefficients for RSV and influenza were -0.84 ($p = 0.051$) and -0.89 ($p = 0.008$), respectively. These values indicate a significant negative association between increased hand hygiene compliance and decreased transmission of these respiratory viruses. Furthermore, an additional study (C. Han et al. 2021) corroborated the identical association between adherence to hand hygiene measures and the occurrence of Healthcare-Associated Infections. The outcomes from four years of intervention demonstrated a weak significant negative association between them ($r = -0.27$; $P = 0.037$). Also study conducted in Saudi Arabia reveals a weak negative association between compliance with Hand Hygiene and the rate of Healthcare-Associated Infections (Al Kuwaiti 2017).

These results underscore the importance of emphasizing and improving hand hygiene practices as a potential intervention strategy to mitigate the yearly incidence of HA-RVIs. This asserted by a (Hillier 2020) study that conclude maintain effective hand hygiene practices is crucial in preventing healthcare-associated infections, curbing cross-infections, and mitigating antimicrobial resistance dissemination.

6.6.2 Transmission-based precautions compliance

The data on compliance with transmission-based precautions (TBP) provides valuable insights into the extent to which healthcare workers adhere to measures aimed at preventing the transmission of infections. The data indicates that all wards exhibit a high level of compliance with TBP, with mean compliance rates ranging from 91.6% to 93.8%. The yearly mean TBP compliance has experienced some fluctuations over the years, starting at 95.3% in 2018 and decreasing to 93.6% in 2022. The hospital has demonstrated a consistent commitment to TBP, with mean compliance rates remaining above 90% in all years and hospital wards.

Despite the good adherence to TBP and the low incidence level, a positive relationship has undertaken between TBP and the incidence of HA-RVIs. That means the high compliance to TBP increased the incidence of HA-RVIs. This association raises questions regarding the potential factors that contribute to this relationship. For example, is it attributed to variations in healthcare workers' awareness and training effectiveness? Would it be in the way of monitoring and feedback protocols? Would it be in the variations in cultural beliefs within families concerning the acceptance of preventive measures?

6.6.3 Environmental cleaning compliance

The data of environmental cleaning compliance is of utmost importance as it serves as a key indicator of healthcare workers' adherence to recommended cleaning practices within the facility. All wards demonstrate a commitment to maintaining a clean healthcare environment, with mean compliance rates above 90%. The yearly mean environmental cleaning compliance has exhibited a degree of variability over the years, starting at 94.5% in 2018, peaking at 97% in 2022, and slightly decreasing in 2021 to 88.5%.

It is noteworthy, however, that despite the high level of environmental cleaning compliance, a positive significant association appears between environmental cleaning and incidence HA-RVIs. This means higher levels of environmental cleaning are associated with an increased incidence.

Accordingly, a safe environment may play an important role in preventing the spread of HA-RVIs, but other factors could be contributing to this. Starting the safe environment as a concept. Would this concept need to be expanded or altered?

In addition, who is responsible for maintaining a safe environment? Would it be a joint responsibility of a multidisciplinary team? If the multidisciplinary team is responsible, how is the team dynamic important, and whether different roles and backgrounds of this team may interfere in maintaining a safe environment?

6.6.4 Visitor restriction

The analysis of yearly incidence data suggests a statistically significant reduction in incidence rates following the implementation of the visitor restriction policy. Before its implementation, the mean incidence was recorded at 1.39, indicating a higher occurrence rate. However, following the visitor restriction policy implementation, the mean incidence rate decreased significantly to 0.92, with a p-value of 0.000. These results offer evidence that the visitor restriction policy implementation has effectively contributed to the lowering of the yearly incidence of the studied phenomenon. In constant with previous study (Forkpa et al. 2020) that indicates that the transmission index for HA-RVIs showed a notable 59% decrease during the months when visitor restrictions were enforced. Similarly, another study declared that after the implementation of the visitation policy, which limited visitor entrance during a patient's hospital stay, a significant 37% decrease in HA-RVIs. This suggests that the new visitation policy played an important role in preventing the occurrence of HA-RVIs in the hospital (Washam et al. 2018).

6.6.5 Multiple linear regression of infection control measures:

The results of the multiple linear regression analysis reveals the associations between infection control measures and yearly incidence of HA-RVIs. The model exhibits high overall significance ($p < 0.05$) and high R-squared value of 0.858, emphasizing the impact of Transmission Based Precautions, Hand Hygiene, and Environmental Cleaning in explaining the variability in yearly incidence of HA-RVIs. Higher scores in Transmission Based Precautions and Environmental Cleaning are positively associated with increased yearly incidence, while higher scores in Hand Hygiene are inversely related to Yearly Incidence.

These findings provide valuable insights into infection control measures and suggest that multi-component infection control strategies, emphasizing Hand Hygiene, and considering nuances in the implementation of transmission-based precautions and environmental cleaning, can significantly impact the yearly incidence of HA-RVIs. These results contribute to the broader understanding of infection control strategies and can inform targeted interventions to reduce yearly incidence of HA-RVIs in healthcare facilities.

6.7 Conclusion

This study represents the first study in Palestine focused on healthcare-associated infections, particularly viral respiratory infections. The study delves into the characteristics and consequences of these infections and evaluates the impact of an infection control multi-component in containing their spread within the hospital setting.

This study is a retrospective cohort study adopted to meet the objectives of this study. Our findings align with results from international studies, contributing valuable insights to the global understanding of healthcare-associated infections and the impact of infection control measures in preventing these infection.

The present study describes the incidence, etiology, patient medical health status and outcomes of HA-RVIs over a five-year period. A total of 82 cases were identified, of which 50 were definite and 32 were possible cases. The incidence rate was found to be 1.02 per 1000 admission days, with 0.62 and 0.40 rates for definite and possible cases, respectively. The year 2019 had the highest incidence rate of 1.6 per 1000 AD. The most commonly identified viruses were RSV, parainfluenza viruses, and adenovirus, with incidence rates of 0.42, 0.20, and 0.19, respectively. Infants were the most affected age group. Nearly 98.8% of the patients with HA-RVIs presented with respiratory symptoms at the time of testing, while fever was reported in 78% of cases. Additionally, 61% of HA-RVI cases had one or more underlying comorbidities, with neonatal, respiratory, genetic, endocrine, and cardiological disorders being the most commonly reported comorbidities. The presence of comorbidities is associated with an increased risk of overall HA-RVIs (odds ratio=3.31) and Definite HA-RVIs (odds ratio=1.64). Among patient outcomes, 37.8% of HA-RVI cases required respiratory escalation support, with RSV and parainfluenza viruses requiring more respiratory support. A high percentage of infants and neonates required such support, while 8.5% of HA-RVI cases necessitated ICU transfer. Two deaths of HA-RVIs cases occurred during study period. On average, patients with HA-RVIs had a length of stay of 18.5 days, which was longer than that of non-HA-RVI cases. Definite cases had a higher mean length of stay than possible ones. Cases with RSV tended to experience shorter hospital stays than those with other viruses, and children exhibited the lowest mean length of stay.

The study provides valuable insights into the trends over years in incidence, characteristics, and outcomes of HA-RVIs. These findings demonstrate that HA-RVIs are a significant public health concern with infants being the most affected age group.

The study also assessed the impact of infection control multi-component on the incidence of HA-RVIs. These measures include hand hygiene compliance, transmission-bases precautions (TBP), environmental cleaning, and visitor restrictions. The results indicate a positive trend in hand hygiene compliance across years and wards, with a significant negative association between hand hygiene and yearly incidence. This suggests that a higher degree of hand hygiene compliance is associated with a reduction in the incidence of HA-RVIs. The implementation of the visitor restriction policy has effectively contributed to the lowering of the yearly incidence.

TBP and Environmental cleaning compliance and have consistently remained above 90%. However, a significant positive association between them and the incidence of HA-RVIs was observed. To reverse this positive association and aim for a negative relationship, a comprehensive approach needs to be undertaken such as promote interdisciplinary collaboration, implement quality improvement initiatives to systematically address any deficiencies and take account for cultural factors that may impact the acceptance of preventive measures by families, so that effective strategies to mitigate the incidence of HA-RVIs can be developed.

In conclusion, the hand hygiene compliance data suggests that CBH places a strong emphasis on maintaining hand hygiene standards across various wards, contributing to infection prevention and control efforts.

The infection control multi-component program was implemented in the CBH emerges as a pivotal strategy in the prevention and management of HA-RVIs. Overall, these findings underscore the importance of continuous monitoring, assessment, and refinement of multi-component infection control programs to enhance patient safety and minimize the impact of HA-RVIs in healthcare settings.

In conclusion, the multi-component program implemented at CBH is an impressive initiative that highlights the hospital's commitment to ensuring the safety of its patients and healthcare workers. The adoption of standard and transmission-based precautions, as well as the use of monthly indicators to monitor compliance, are proactive measures that promote a culture of safety within the hospital. As such, the impact of the program is measurable, and it stands as a testament to the hospital's dedication to providing high-quality care.

6.8 Study limitation

- The study's retrospective nature entails the reliance on previously recorded electronic health data
- The study was conducted in a single children's hospital, which may limit the generalizability of the findings to other hospitals with different geographic regions and hospital populations

6.9 Recommendation:

- Set up a standard definition of healthcare-associated respiratory viral infections (HA-RVIs) at the national level to make it easier to compare between hospitals and monitor public health trends.

- Develop a national policy to prevent HA-RVIs, which should contain preventive measures, guidelines for healthcare workers, and adaptable protocols for managing HA-RVIs.
- Create a surveillance system for tracking HA-RVIs and prompt responses to emerging outbreaks
- Encourage a culture of continuous learning and adaptation to evolving best practices.
- Establish a continuous quality improvement framework to monitor and address deficiencies in infection control practices.
- Recommend further studies, including qualitative observations and prospective studies, to develop an insightful understanding about the implementation of infection control program into practice in various hospital sitting and geographical areas.

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Appendix:

Appendix 1: Approval letter from research ethical committee of public health collage

Al-Quds University Jerusalem School of Public Health	**جـامـعـة الـقـدس** القدس كلية الصحة العامة

التاريخ: **31/1/2023**

عزيزتي الطالبة نور جابر المحترمة

برنامج ماجستير الوقاية وضبط الامراض المعدية

الموضوع: موافقة لجنة اخلاقيات البحث العلمي

قامت اللجنة الفرعية لأخلاقيات البحث التابعة لكلية الصحة العامة بمراجعة مشروع الرسالة بعنوان:

"Respiratory viruses healthcare-associated infections among hospitalized children at Caritas Baby Hospital: The impact of the infection control program"

المقدم من (مشرف البحث/د. موسى هندية).

يعتبر مشروعك مستوفيًا لمتطلبات أخلاقيات البحث في جامعة القدس.

نتمنى لكم كل التوفيق في تسيير المشروع.

ملاحظة: في حالة الحاجة الى موافقة من اللجنة المركزية في الجامعة، تستطيع التقدم باستخدام هذه الموافقة على الرابط.https://research.alquds.edu/en/ethics/48-how-to-apply.html

رئيسة اللجنة الفرعية لاخلاقيات البحث

كلية الصحة العامة

د. نهى الشريف

نسخة/ أعضاء لجنة البحث

نسخة/ الملف

Jerusalem Branch/Telefax 02-2799234 Gaza Branch/Telefax 08-2644220 -2644210 P.O. box 51000 Jerusalem	فرع القدس / تلفاكس 02-2799234 فرع غزة / تلفاكس 08-264420-2644210 ص.ب. 51000 القدس

Appendix 2: The ethical approval to start the study from Caritas Baby Hospital

Children's Relief **Bethlehem**

Caritas Baby Hospital
P.O. Box 84, Bethlehem
Tel. +972 2 275 85 00, Fax +972 2 275 85 01
info@crb-mail.org, www.childrens-relief-bethlehem.org
Arab Bank, Bethlehem, Acct. 702280

Medical Research Agreement of Principles

Date: 20-1-2023

This is to certify that Caritas Baby Hospital represented by: __**Dr. Musa Hindiyeh**__ will be collaborating with ____ **Alquds University** ______ represented by: _ **Al-Quds University**___ to conduct a Medical Research Project entitled: _ **Respiratory viruses healthcare associated infections among hospitalized children at Caritas Baby Hospital: The impact of the infection control program** ___. The research project will be conducted by: _____**Nur Adnan Jaber** ____________. Mrs Jaber will have access to all the data that is related to this project.

The above research project was reviewed by memebrs of Caritas Medical Research Committee and was approved on____**15-10-2022**_____ and given MRC-Project Number ___________**MRC-47**______________________________.

After the fruitful accomplishment of the project both parties agree to publsih the work in peer reviewed journal and the authorship location in the manuscript will be as follows:

First author: **Nur Adnan Jaber**
Second author:
Third author:
Before last author:
Last author: **Musa Hindiyeh**

Caritas Baby Hospital
Medical Rearch Committe Representative
Dr. Musa Hindiyeh