MAGNITUDE AND ASSOCIATED FACTORS OF VENTILATOR-ASSOCIATED PNEUMONIA IN PEDIATRIC INTENSIVE CARE UNIT, TASH ADDIS ABABA, ETHIOPIA

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Magnitude and Associated Factors of Ventilator-Associated Pneumonia in Pediatric Intensive Care Unit, TASH Addis Ababa, Ethiopia

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Contents

List of acronyms

AOR:	Adjusted odds ratio
CDC:	Center of disease control and prevention
DOE:	Date of event
HAI:	Healthcare associated infection
VAP:	Ventilator-Associated Pneumonia
WHO:	World health organization
LMICs:	Low- and middle-income countries
PI:	Principal Investigator
SPSS:	Statistical Package for Social Sciences version 25
SD:	Standard deviation
TASH:	Tikur Anbessa Specialized Hospital

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Abstract

Background: Ventilator-associated pneumonia (VAP) is a lung infection that occurs in patients who have been receiving mechanical ventilation through an endotracheal or tracheostomy tube for more than 48 hours. [1]. In critically ill children, VAP is a severe complication which can lead to an increased length of stay in the hospital along with increased costs of healthcare services due to increased morbidity and mortality rates [2, 3, 4, 5]. However, it seems that concerning VAP, there is not much research done in Ethiopia concerning this critical problem.

Objective: This study aimed to describe Magnitude and Associated Factors of Ventilator-Associated Pneumonia in Pediatric Intensive Care Unit, TASH Addis Ababa, Ethiopia

Methods: A retrospective Hospital-based cross-sectional study design was used. A total of 250 patient records kept in TASH from September 11, 2019 to January 8, 2025. Data were collected by using a checklist through Google form and analyzed using SPSS version 27 software package. Mean and standard deviation were used to describe Continuous data and frequency and percentage were used to describe categorical data to identify factors associated with the VAP, bi-variable analysis with P value <0.25 and multivariable analysis with P value <0.05 binary logistic regression analyses were performed. Statistical significance was set at a 5% level, and adjusted odds ratios (AOR) with 95% confidence intervals (CI) were calculated to present the strength of the associated factors.

Result: A total of 250 patients were included (56.4% male), with a median age category of 1–5 years. 16.8% of patients had ventilator-associated pneumonia (VAP) (95% CI: 12.4%–22%). VAP was more common among males (78.6%) and in patients older than 5 years (47.6%). Patients with VAP had a significantly longer mean duration of mechanical ventilation (18.0 ± 9.9 vs. 6.1 ± 6.1 days) than patients without the condition.

The most common admission sources were Emergency OPD (49.6%) and pediatric ward (27.6%). Acute respiratory failure (52.8%) and impaired consciousness (41.2%) were the leading indications for ventilation.

Frequent comorbidities included malignancy (7.6%) and severe acute malnutrition (5.6%).

The most prevalent risk factors were nasogastric tube (NGT) feeding (20.1%), continuous intravenous sedation (15.8%), and steroid use (15.3%), followed by PPI use (12%), aspiration (7.7%), and re-intubation (5.3%).

Conclusion: Ventilator-associated pneumonia (VAP) was identified in 16.8% of mechanically ventilated children in the PICU at TASH. VAP was associated with prolonged ventilation and was more frequent in older children and males. Common risk factors included NGT feeding, continuous IV sedation, and steroid use. To lessen the burden of VAP, prevention measures must be strengthened and modifiable risk factors must be addressed.

Key words: Magnitude, Ventilator associated Pneumonia, pediatrics, ICU, Factors TASH, Ethiopia

1. Introduction

1.1. Background

VAP, or ventilator-associated pneumonia, is a serious infection that usually appears more than 48 hours after the start of mechanical ventilation in patients (1). VAP accounts for approximately 25% of all ICU infections worldwide and affects 2-35% of ventilated patients, making it the most common ICU-acquired infection (14). Due to the need for prolonged antibiotic use and hospital resources, this condition not only lengthens ICU stays but also significantly raises morbidity, mortality, and healthcare costs (13, 14). Because VAP lengthens hospital stays and increases the risk of death, it makes caring for critically ill pediatric patients much more difficult (9,7).

The management of VAP is made more difficult for pediatric patients in low-resource environments by additional obstacles such as restricted access to Additional challenges, such as limited access to advanced medical equipment and trained healthcare personnel, complicate the management of VAP for pediatric patients in low-resource settings (12). In addition, the presence of a tracheostomy and the requirement for re-intubation have been recognized as separate risk factors for VAP (7).

Elevation of the head of the bed, sedation interruptions, careful oral hygiene, and subglottic secretion drainage are effective VAP prevention strategies. However, their implementation varies, especially in settings with limited resources, which has a significant impact on VAP rates (13, 14). The variety of the microbial flora that causes VAP, including common organisms like Pseudomonas, Klebsiella, and E. coli, makes treatment more difficult because of different resistance patterns (9, 7).

In Ethiopia, data on the incidence and risk factors of VAP in PICUs are limited, particularly at Tikur Anbessa Specialized Hospital (TASH), one of the largest and most advanced tertiary care centers in the country. Developing effective prevention and management strategies that are suited to the unique challenges in the Ethiopian healthcare setting requires an understanding of the local epidemiology and risk factors associated with VAP (12).

This study aimed to fill this gap by retrospectively examining the magnitude and associated factors of VAP among pediatric patients in the PICU at TASH. This study aims to inform improved

clinical practices and policymaking by determining the incidence and important risk factors, including demographics, underlying medical conditions, and the length of mechanical ventilation (13, 7). These findings will also help guide the implementation of evidence-based strategies to lower the incidence and impact of VAP in Ethiopian PICUs and advance global understanding of VAP in pediatric populations, especially in settings with limited resources (12, 14).

1.2 Statement of the problem

Ventilator-associated pneumonia (VAP) continues to be one of the biggest problems in intensive care units (ICUs) around the world, especially in places with limited resources like Ethiopia (12). The CDC reports that VAP is the most prevalent and dangerous hospital-acquired infection that causes high rates of morbidity and mortality in patients on mechanical ventilation (1). VAP remains a major cause of extended intensive care unit stays, elevated healthcare expenses, and unfavorable outcomes, even with advancements in medical technology and infection control procedures (11). In pediatric intensive care units (PICUs), where vulnerable groups, such as infants

and children with weakened immune systems, are particularly at risk, this problem is particularly severe (7–10)

In Ethiopia, the burden of VAP is largely underreported and inadequately studied, especially in major healthcare centers such as Tikur Anbessa Specialized Hospital (TASH), one of the largest and most advanced tertiary care facilities in the country (12). The World Health Organization (WHO) highlights that the development of effective prevention strategies and patient safety are compromised in settings with limited resources due to the lack of comprehensive data on healthcare-associated infections, such as VAP (16). A major obstacle to implementing focused prevention and management strategies has been the lack of comprehensive epidemiological data on the incidence and risk factors of VAP in pediatric patients at TASH (12). It is difficult for healthcare providers to create evidence-based protocols that meet the particular requirements of the Ethiopian healthcare system in the absence of such vital data.

The variability in microbial flora responsible for VAP, coupled with the rising threat of antibiotic resistance, further complicates treatment, making it difficult to standardize care across different settings (10, 13). The CDC notes that antimicrobial resistance is a growing concern in the treatment of VAP, particularly in developing countries where access to advanced antibiotics may be limited (1). The absence of localized studies exacerbates these issues, limiting the ability to address the specific needs of the Ethiopian pediatric population, potentially leading to suboptimal care and higher mortality rates.

Given the critical role that TASH plays in providing advanced pediatric care, it is imperative to investigate the magnitude and associated risk factors of VAP within this institution. Understanding these factors is essential for developing effective interventions that can reduce the incidence of VAP, improve patient outcomes, and ultimately enhance the quality of care for critically ill children in Ethiopia.

By providing a thorough analysis of VAP in pediatric patients at TASH, this study aims to close this gap and guide the development of policies and clinical practices to better manage and prevent VAP in settings with limited resources.

1.3 Significance of the study

The significance of studying ventilator-associated pneumonia (VAP) in pediatric intensive care units (PICUs) at Tikur Anbessa Specialized Hospital (TASH) in Ethiopia cannot be overstated, given its serious implications for patient outcomes, including increased morbidity, extended hospital stays, and elevated healthcare costs. Understanding the magnitude and associated factors of VAP in this resource-constrained environment is critical for several reasons. Firstly, it directly contributes to improving patient outcomes; by identifying how VAP affects pediatric patients and pinpointing associated risk factors, healthcare providers can enhance clinical management and reduce VAP incidence through targeted interventions and preventive measures. Such insights are particularly valuable in optimizing infection control practices in environments where resources are constrained. For instance, identifying prolonged mechanical ventilation as a significant risk factor allows for the development of protocols aimed at minimizing ventilation duration, thus potentially mitigating one of the primary risk factors for VAP.

Second, by providing a standard for assessing and improving current procedures at TASH and other comparable settings, the study's findings will aid in the improvement of infection control protocols. This can lead to more effective, context-specific infection control measures tailored to meet the unique challenges faced in Ethiopian PICUs. Moreover, this research will fill significant gaps in the current literature by providing detailed, context-specific data on VAP, which is scarce for Ethiopian PICUs. Such data are invaluable not only for local healthcare practitioners but also for the global medical community, aiding researchers and policymakers in understanding and addressing VAP in comparable contexts.

Furthermore, the study will inform policy and educational programs by emphasizing the importance of specific preventive measures and management strategies. The results could influence training programs for healthcare professionals, highlighting critical areas for intervention and prevention. Additionally, the evidence generated could support advocacy efforts for better resource allocation and enhanced support for PICUs across Ethiopia, ultimately improving patient care.

In conclusion, this study has the potential to significantly advance our understanding of VAP in pediatric intensive care settings worldwide, guide clinical management, shape preventive

strategies, and provide crucial information on the prevalence and risk factors of VAP in a critical care setting.

2. Literature Review

2.1. Prevalence

Ventilator-associated pneumonia (VAP) remains a critical concern in pediatric intensive care units (PICUs) across various regions, particularly in resource-limited settings. Depending on the region and the particular healthcare setting, the prevalence of VAP varies greatly. For instance, in a study conducted at the Children's Hospital and Institute of Child Health in Lahore, Pakistan, the prevalence of VAP was reported to be 17% among mechanically ventilated children(9). A study from a PICU in Milan, Italy, found a lower prevalence rate of 6.6%, highlighting regional differences in VAP rates(7). In Ethiopia, VAP prevalence was reported at 18.6% in Tikur Anbessa Specialized Referral Hospital, demonstrating a substantial burden of VAP in this setting(12). My

thesis aims to fill this gap by providing accurate prevalence data from our tertiary hospital, which will contribute to a better understanding of VAP in resource-limited settings.

2.2. Associated factors

2.2.1 Sociodemographic Factors

Age and gender have a significant impact on VAP susceptibility; infants under one year old are particularly at risk (9, 24, and 25). According to a study from Tikur Anbessa Specialized Hospital, 39.1% of patients on mechanical ventilation were under a year old, which puts them at higher risk for complications like VAP (12). In addition, a number of studies have consistently shown that VAP is more common in men (12, 26). The risk is increased when underlying conditions like immunosuppression and malnutrition are present (3). My research will explore how these factors play out in our specific context, offering insights that are directly applicable to our patient population.

2.2.2 Characteristics of Mechanical Ventilation (MV)

The type and duration of mechanical ventilation are significant factors that impact the risk of ventilator-associated pneumonia. One important factor is the length of time on mechanical ventilation; longer ventilation (more than four days) is linked to a higher incidence of ventilator-associated pneumonia (VAP) (7, 12). The risk of developing VAP is increased by re-intubation, a critical risk factor, which disrupts airway defenses (7).

In the Ethiopian context, synchronized intermittent mandatory ventilation (SIMV) was the most commonly used mode, employed in 80% of cases, reflecting global practices where SIMV is frequently preferred due to its flexibility in managing pediatric respiratory failure(12).My thesis will investigate how factors like re-intubation and MV duration affect VAP development in our hospital, providing evidence that could inform local clinical practices

2.2.3 Nursing Care (Infection Prevention Methods, Oral Care, Positioning, Transport Out of the PICU)

Effective nursing care is essential for preventing VAP, and several methods are suggested to reduce the risk of infection (1). It is commonly acknowledged that raising the head of the bed to 30° to 45° lowers the risk of VAP by avoiding aspiration (7). Oral care, particularly with antiseptics

like chlorhexidine, has been shown to significantly lower the rate of VAP by reducing oropharyngeal colonization of pathogens (7). Moreover, minimizing the transport of ventilated patients out of the PICU is crucial in reducing exposure to external pathogens(14) My research will evaluate current nursing protocols and their impact on VAP rates in our PICU, with the goal of recommending context-specific improvements.

2.2.4 Patient Characteristics (Impaired Consciousness, Genetic Syndrome, ARDS, Bloodstream Infection, Fluid Balance, Enteral Feeding, Length of ICU Stay)

Certain patient characteristics are closely linked to the development of VAP. Acute respiratory distress syndrome (ARDS), genetic syndromes, and impaired consciousness put patients at higher risk because of weakened immune systems and extended reliance on mechanical ventilation (7, 12). The use of enteral feeding, though necessary, has been associated with an increased risk of aspiration and subsequent VAP (14). Additionally, the length of ICU stay is both a risk factor for and a consequence of VAP, with prolonged stays leading to a higher incidence of the infection (12).My study will examine these factors in our setting, providing data that could lead to more By analyzing these variables in our context.

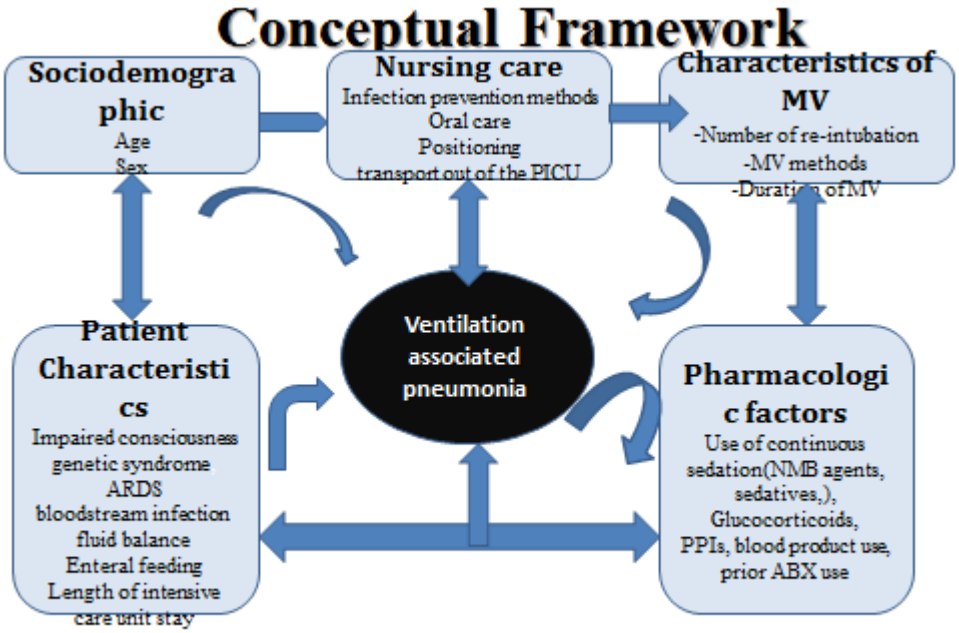

Fig 1: - Conceptual framework

Conceptual framework made from reviewing relevant literatures 8,11,12

3. Objective

3.1. General objective

- To assess the magnitude and the factors associated with Ventilator-Associated Pneumonia (VAP) among pediatric patients in the Intensive Care Unit (ICU) of Tikur Anbessa specialized Hospital, Addis Ababa, Ethiopia.

3.2. Specific objectives

- To determine the magnitude of Ventilator-Associated Pneumonia in patients admitted to the pediatric Intensive Care Unit during the study period.
- To identify associated factors contributing to the occurrence of Ventilator-Associated Pneumonia in the pediatric patients under mechanical ventilation.

4. Method and Materials

4.1. Study area and period

The study was conducted in Tikur Anbessa Specialized Hospital from September 11, 2017 to January 8, 2025

Tikur Anbessa Specialized Hospital,the largest referral and teaching hospital in Addis Ababa, Ethiopia's capital. The hospital has a Pediatric Intensive Care Unit (PICU) with six beds. Three fellows in pediatric pulmonary and critical care, one pediatric emergency and critical care physician, and one pediatric pulmonary. The nurse-to-patient ratio was 1:2, and pediatric residents were attached to the unit. However, no respiratory therapists are currently available. The PICU was equipped with four mechanical ventilators, including monitors with end-tidal CO2 monitoring capabilities. Patients must be transported to an X-ray machine located one floor away because the portable X-ray machine shared with the nearby adult intensive care unit is not always operational. All patients received mechanical ventilation through an endotracheal tube, and clinical examinations and chest X-rays were ordered as needed for monitoring. All children who received mechanical ventilation received sedation through intermittent doses of diazepam and morphine. Neuromuscular blocking agents have never been used, and thiopental and propofol are rarely used. Infusion pumps are not always available, but when they are, continuous infusion sedation is used.

4.2. Study design

- A Hospital based retrospective cross-sectional study was carried out.

4.3. Population

4.3.1. Source population

- All pediatric patients admitted to the pediatric intensive care unit (PICU) of Tikur Anbessa Specialized Hospital

4.3.2. Study population

- All pediatric patients admitted to the pediatric intensive care unit (PICU) of Tikur Anbessa Specialized Hospital in the study period from September 11, 2017 to January 8, 2025

4.4. Eligibility

4.4.1 Inclusion

- Pediatric patients (starting from 8 days to 16 years) receiving mechanical ventilation in the intensive care unit
- Pediatric patients with a minimum duration of mechanical ventilation of 48 hours

4.4.2 Exclusion criteria

- Patients outside the defined paediatric age range,
- Patients not receiving Mechanical Ventilation
- Very short duration of mechanical ventilation (less than 48 hours)

4.5. Sample size determination

4.5.1. Sample size determination

The sample size was determined using a single population proportion formula, with a confidence level of 95%, a marginal error of 5%, and a proportion of 80%. This calculation was based on previously published data regarding the VAP, specifically a study conducted at Tikur anbessa specialized hospital, TASH which estimated a prevalence of 0.205. (12)

Sample size: $N=\frac{Z^2P(1-P)}{d^2} = \frac{(1.96)^2*0.205*(1-0.205)}{(0.05)^2} = 250$

Where: N= the minimum sample size

p=the expected prevalence of VAP 20.5 % (from previous research)

d= the level of precision (margin of error)

z= the value at 95% confidence level

4.6 Data Collection Tool and Procedures

After selecting the study cases, Structured Checklist assessment tool was used that encompasses Socio-demographic data, clinical characteristics and potential factors. Then the principal investigator collects the data by chart reviewing from pediatric clinic. Google form was used to collect the data along with the Gmail server to store the collected data.

4.7 Data Quality control and management

To ensure the quality of data, Google form was used. Each question was properly coded; The collected data were checked for completeness and consistency on each day of data collection by principal investigator.

4.8. Variables

4.8.1 Outcome variable

- Magnitude of VAP

4.8.2 Explanatory variables

- Socio-demographic data: age, sex
- Clinical characteristics Duration, Admitted from, indication for mechanical ventilation, comorbidities and
- Potential risk factors (tracheostomy, bronchoscopy, re-intubation, aspiration of gastric content, NGT and enteral feeding, transportation out of the ICU, use of steroids, use of proton pump inhibitors (PPI), Continuous intravenous sedation Surgical drainage and Compliance with VAP

4.9. Operational Definition

Ventilator-Associated Pneumonia (VAP): Pneumonia occurring ≥48 hours after mechanical ventilation, diagnosed using NNIS/CDC clinical criteria.

Diagnostic Criteria:

Chest X-ray Findings (≥2 in most cases, 1 if no underlying lung/heart disease)

- New/progressive infiltrate, consolidation, cavitation, or pneumatoceles (infants ≤1 year).

Clinical Signs & Symptoms:

- Infants ≤1 year: Worsening gas exchange + ≥3 (temp instability, apnea, grunting, wheezing, tachycardia).
- Children >1 to ≤12 years: ≥3 (fever/hypothermia, leukocytosis/leukopenia, worsening gas exchange, rales).

- Adolescents >12 years & Adults: ≥2 (fever/hypothermia, leukocytosis/leukopenia, purulent sputum, worsening oxygenation, new/worsening cough).[1]

4.10. Data processing and Analysis

After data collection with Google form, each completed forms were checked for completeness and exported to SPSS version 27 for analysis. Mean, and standard deviation were used to describe Continuous data; and frequency and percentage were used to describe categorical data. To identify factors associated with VAP, first, Bivariable analysis was done. Then variables with a P-value < 0.25 in a Bivariable analysis were selected as candidate variables to be entered together into a multivariable analysis. Lastly, variables with a p-value < 0.05 in multivariable analysis were employed as statistically significant and AOR with 95% CI were identified to measure the strength of the associations. The result is presented by using text, tables and graphs, and finally interpreted into valuable information.

4.11. Ethical consideration

Ethical clearance was obtained from the Department of Research and Ethical Review Committee (DRERC). Then an official letter of support and ethical clearance was submitted to the Record office. Confidentiality was maintained at all levels of the study, besides only the MRN number of study participants were used without mentioning the name and the collected information was kept in a secured place.

4.12. Dissemination and utilization of results

The finding of this research will be submitted to Addis Ababa university health science and medical college,departement of pediatrics and child health and will be presented during the final defense for partial fulfillment of speciality. The finding of the study will also be shared other concerned bodies. Subsequently an attempt will be made to present the findings on different review meetings, seminars, and workshops Furthermore, the manuscript will be published on peer reviewed journals

5. Result

5.1 Magnitude of VAP

In this study, 250 participants were participated making the response rate 92.5 %. More than half of the participants are male (141, 56.4%), while (109, 43.6%) are female. Participants were distributed across three age groups: 30.8% (77) were between 8 days and 1 year, 35.2% (88) were between 1 and 5 years, and 34.0% (85) were older than 5 years. The magnitude of ventilated associated pneumonia in the pediatric intensive care unit of TASH was found to be 16.8 % (42); 95% CI: 12.4 – 22%. A quarter of the patients with VAP were female (9, 21.4%), while nearly three-quarters were male (33, 78.6%). The male to female ratio in this case is approximately 3.6:1. Nearly half of the cases (18, 47.6%) were older than 5 years, about one-third of the cases (15, 35.7%) between 1 and 5 years and the remaining cases were in patients aged between 8 days and 1 year (7, 16.7%).

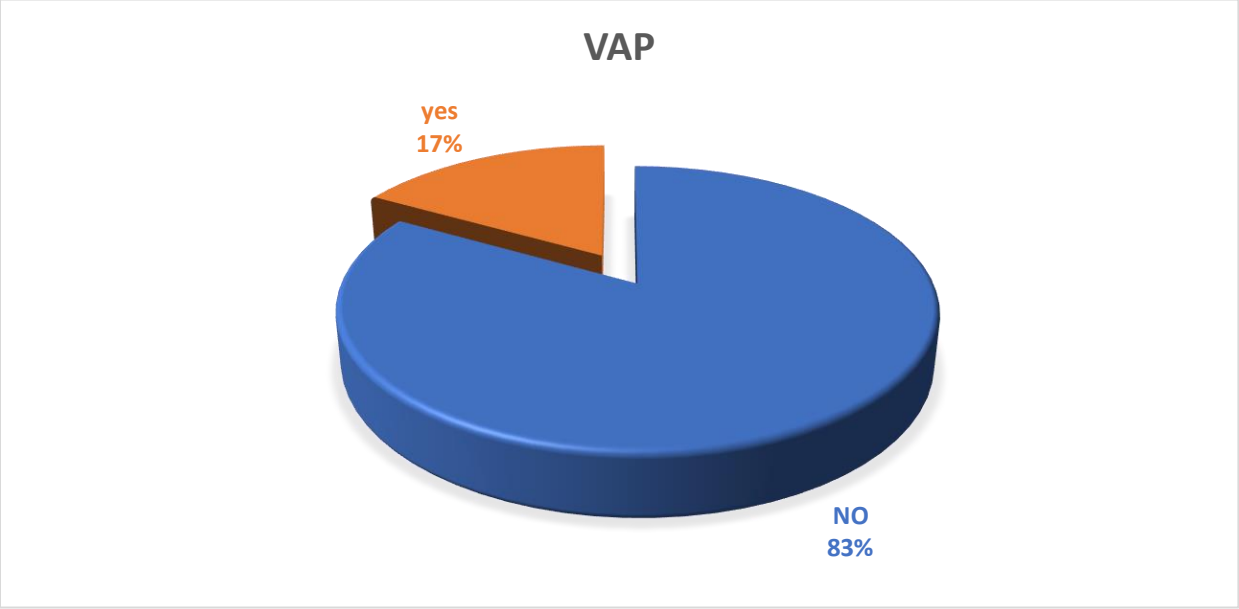

Fig. 2 *Magnitude of VAP at the Pediatric Intensive Care Unit (PICU) of Tikur Anbessa Specialized Hospital.*

5.2 Clinical characteristics

The average duration of mechanical ventilation in this study was 8.04 ± 8.13 days, with a range from 0 to 52 days. Patients with Ventilator-Associated Pneumonia (VAP) had a longer average ventilation duration of 18.03 ± 9.92 days, while those without VAP had an average of 6.14 ± 6.14 days. Regarding the onset of VAP after intubation, 40% (16 patients) developed VAP within 7 days, while 60% (24 patients) developed it after 7 days.

Nearly half of the patients (124, 49.6%) were admitted from the Emergency OPD, with more than quarter (69, 27.6%) coming from the pediatric ward and about (57, 22.8%) from the operative room. The primary indications for mechanical ventilation were more than half due to acute respiratory failure (132, 52.8%) and about (103, 41.2%) due to coma or impaired consciousness, while neuro-muscular diseases accounted for (15, 6%). Regarding the primary diagnoses, nearly a quarter of cases were due to respiratory diseases (61, 24.4%), more than a quarter to neurologic/neurosurgical disorders (65, 26%), and about (31, 12.4%) to cardiovascular disorders (31, 12.4%), with smaller groups related to sepsis/septic shock (24, 9.6%), metabolic or renal disorders (33, 13.2%), and intra-abdominal disorders (12, 4.8%). Trauma, poisoning, post-operative follow-up, and other conditions made up a small proportion of cases

Nearly half of the patients (118, 47.2%) had comorbidities, Specific conditions observed included malignancy (19, 7.6%), immunocompromised status (1, 0.4%), chronic kidney disease (4, 1.6%), severe acute malnutrition (14, 5.6%), and other conditions (46, 18.4%).

Table 1 clinical characteristics of the study population

		Frequency	Percent
Admitted to ICU from	Pediatric ward	69	27.6
	Emergency OPD	124	49.6
	Operative room	57	22.8
	Total	250	100.0
Primary indication for mechanical ventilation	Acute respiratory failure	132	52.8
	Coma or impaired consciousness	103	41.2
	Neuro-muscular diseases	15	6.0
	Total	250	100.0
Primary indication for mechanical ventilation	Trauma	3	1.2
	respiratory disease	61	24.4
	Neurologic/ neurosurgical disorder	65	26.0
	Cardiovascular disorder	31	12.4
	intra-abdominal disorder	12	4.8
	Poisoning	3	1.2
	Metabolic or renal	33	13.2
	post-operative follow up	15	6.0
	sepsis /septic shock	24	9.6
	other	3	1.2
	Total	250	100.0
Presence of Co-morbidity	Yes	202	80.8
	No	48	19.2
	Total	250	100.0
Type	Presence of malignancy (cancer)	19	9.4
	Immunocompromised	1	0.5
	Chronic kidney disease	4	2.0
	SAM	14	6.9
	Other/unknown	46	81.2
	Total	202	100.0

Among the identified risks, NGT feeding is the most common, affecting about (194, 20.1%), followed by continuous intravenous sedation accounts (153, 15.8%) and the use of steroids with about (148, 15.3%). Other significant risk factors include the use of proton pump inhibitors (116, 12%), aspiration (74, 7.7%), and re-intubation (51, 5.3%). Lesser but notable risks include

bronchoscopy (39, 4%), surgical drainage (41, 4.2%), and transportation out of the ICU after intubation (38, 3.9%).

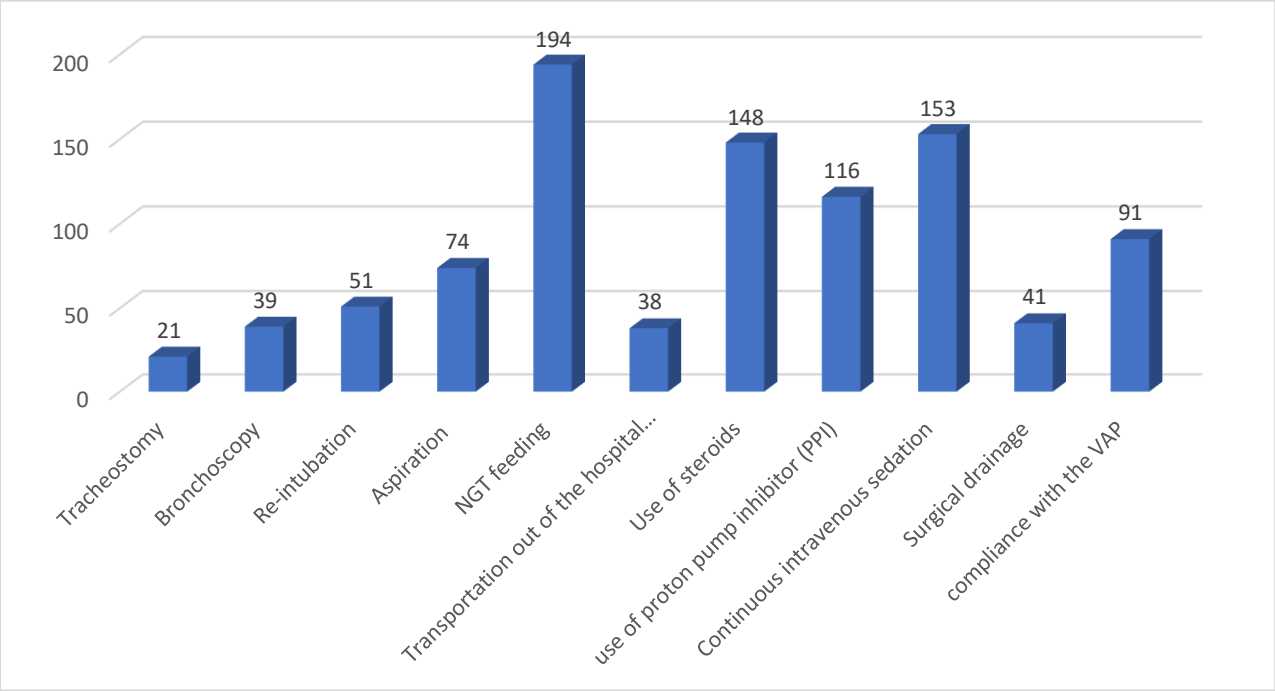

Fig 3 Potential risk factors to develop VAP at the Pediatric Intensive Care Unit (PICU) of Tikur Anbessa Specialized Hospital.

5.3 Factors affecting VAP

In this study, explanatory variables such as: - Age, sex, Duration, Admitted from, indication for mechanical ventilation, comorbidities and potential risk factors (tracheostomy, bronchoscopy, re-intubation, aspiration of gastric content, NGT and enteral feeding, transportation out of the ICU, use of steroids, use of proton pump inhibitors (PPI), Continuous intravenous sedation Surgical drainage and Compliance with VAP were analyzed first by bivariable analysis. Based on the p-value **(< 0.25)** of the bivariable analysis, the following variables were identified as candidate variables for the multivariable analysis these are: Age, sex, ,Duration, Admitted from, indication for mechanical ventilation, comorbidities and potential risk factors (tracheostomy, bronchoscopy, re-intubation, aspiration of gastric content, NGT and enteral feeding, transportation out of the ICU, use of proton pump inhibitors (PPI), Continuous intravenous sedation Surgical drainage and Compliance with VAP

The multivariable analysis presents several key factors that influence the likelihood of developing Ventilator-Associated Pneumonia (VAP). Sex: Males have significantly higher odds of developing VAP (OR = 9.6, 95% CI [2.1-43.4], p = 0.003), with the odds 9.6 times higher compared to females.

Age does not significantly affect the risk of VAP (8 days-1 year: OR = 0.21, 95% CI [0.02-1.63], p = 0.13; 1-5 years: OR = 0.21, 95% CI [0.04-1.20], p = 0.08). Admitted to ICU from: The origin of ICU admission does not show a significant relationship with VAP (Emergency OPD: OR = 7.4, 95% CI [0.6-91.4], p = 0.11). Primary indication for mechanical ventilation: Neither acute respiratory failure (OR = 0.05, 95% CI [0.001-2.34], p = 0.12) nor coma (OR = 0.026, 95% CI [0.001-1.5], p = 0.07) significantly impacted VAP development.

Comorbidity: The presence of comorbidities did not significantly influence VAP risk (OR = 0.10, 95% CI [0.008-1.29], p = 0.78).

The duration of mechanical ventilation in days significantly impacts the odds of Ventilator-Associated Pneumonia (VAP), with an odds ratio of 1.165 (95% CI: 1.113–1.219), indicating that for each additional day of mechanical ventilation, the odds of the VAP occurring increase by 16.5%.

Table 2 Demographic and clinical factor affecting VAP

		Presence of VAP		BV analysis	Multivariable analysis	P value
		No	Yes			
Sex	Female	100 (91.7%)	9 (8.3%)	1	1	
	Male	108 (76.6%)	33 (23.4%)	**2.3[1.5-7.4]**	**9.6[2.1-43.4]**	**0.003**
Age	8 days - 1 yr	70 (90.9%)	7 (9.1%)	0.32[0.12-0.81]	0.21[0.02-1.63]	0.13
	1-5 yrs	73 (83.0%)	15 (17.0%)	0.29[0.66 -3.1]	0.21[0.04-1.20]	0.08
	> 5 yrs	65 (76.5%)	20 (23.5%)	1	1	
Admitted to ICU from	Pediatric ward	57 (82.6%)	12 (17.4%)	3.7[1.0-14.1]	2.06{0.12-35.9]	0.61
	Emergency OPD	97 (78.2%)	27 (21.8%)	5.0[1.4-17.2]	7.4[0.6-91.4]	0.11
	Operative room	54 (94.7%)	3 (5.3%)	1	1	
Primary indication for mechanical ventilation	Acute respiratory failure	115 (87.1%)	17 (12.9%)	0.22[0.07-0.70]	0.05[0.001-2.34]	0.12
	Coma or impaired consciousness	84 (81.6%)	19 (18.4%)	0.33[0.10-1.06]	0.026[0.001-1.5]	0.07
	Neuro-muscular diseases	9 (60.0%)	6 (40.0%)	1	1	
Comorbidity	No	46 (95.8%)	2 (4.2%)	1	1	
	Yes	162 (80.2%)	40 (19.8%)	5.6[1.3-24.3]	0.10[0.008-1.29]	0.78
Duration of mechanical ventilation				**1.16[1.11-1.21]**	**1.34[1.12-1.56]**	**0.0001**

Regarding medical interventions, Tracheostomy significantly decreased VAP risk (OR = 0.003, 95% CI [0.001-0.18], p = 0.005). Bronchoscopy increased VAP risk significantly (OR = 14.6, 95% CI [1.85-115], p = 0.011). Re-intubation (OR = 2.09, 95% CI [0.3-11.8], p = 0.4) and aspiration of gastric content (OR = 1.5, 95% CI [0.27-8.3], p = 0.62) did not show significant associations. NGT and enteral feeding (OR = 12.2, 95% CI [1.28-116.6], p = 0.03) and transportation out of the ICU (OR = 16.17, 95% CI [2.38-109], p = 0.004) both significantly increased VAP risk. Use of proton pump inhibitors (PPI) (OR = 1.83, 95% CI [0.43-7.68], p = 0.4) did not significantly affect VAP risk. Continuous intravenous sedation (OR = 5.8, 95% CI [1.2-26.8], p = 0.02) was significantly associated with an increased risk of VAP. Surgical drainage (OR = 2.5, 95% CI [0.28-22.1], p = 0.4) did not significantly affect VAP development. Lastly, compliance with VAP prevention protocols was significantly protective (OR = 0.005, 95% CI [0.0002-0.12], p = 0.001), reducing the risk of VAP dramatically.

Table 3 Medical interventions factor affecting VAP

		Presence of VAP		**BV analysis**	**Multivariable analysis**	**P value**
		No	**Yes**			
Tracheostomy	No	193 (84.3%)	36 (15.7%)	1	1	
	Yes	15 (71.4%)	6 (28.6%)	2.14[0.78-5.8]	**0.003[0.001-0.18]**	**0.005**
Bronchoscopy	No	180 (85.3%)	31 (14.7%)	1	1	
	Yes	28 (71.8%)	11 (28.2%)	**2.28[1.03-5.05]**	**14.6[1.85-115]**	**0.011**
Re-intubation	No	179 (89.9%)	20 (10.1%)	1	1	
	Yes	29 (56.9%)	22 (43.1%)	6.7[3.3-13.9]	2.09[0.3-11.8]	0.4
Aspiration of gastric content	No	150 (85.2%)	26 (14.8%)	1	1	
	Yes	58 (78.4%)	16 (21.6%)	1.5[0.79-3.1]	1.5[0.27-8.3]	0.62
NGT and enteral feeding	No	54 (96.4%)	2 (3.6%)	1	1	
	Yes	154 (79.4%)	40 (20.6%)	7.0[1.6-30]	**12.2[1.28-116.6]**	**0.03**
Transportation out of the hospital (ICU)	No	183 (86.3%)	29 (13.7%)	1	1	
	Yes	25 (65.8%)	13 (34.2%)	3.2[1.5-7.1]	**16.17[2.38-109]**	**0.004**
Use of proton pump inhibitor (PPI)	No	121 (90.3%)	13 (9.7%)	1	1	
	Yes	87 (75.0%)	29 (25.0%)	3.10[1.5-6.3]	1.83[0.43-7.68]	0.4
	No	92 (94.8%)	5 (5.2%)	1	1	

Continuous intravenous sedation	Yes	116 (75.8%)	37 (24.2%)	5.8[2.2-15.5]	**5.8[1.2-26.8]**	**0.02**
Surgical drainage	No	179 (85.6%)	30 (14.4%)	1	1	
	Yes	29 (70.7%)	12 (29.3%)	2.4[1.1-5.3]	2.5[0.28-22.1]	0.4
Compliance with VAP	No	121 (76.1%)	38 (23.9%)	1	1	
	Yes	87 (95.6%)	4 (4.4%)	0.14[0.05-0.42]	**0.005[0.0002-0.12]**	**0.001**

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6. Discussion

This study was conducted from September 11, 2017, to January 8, 2025, at Tikur Anbessa Specialized Hospital. It was a retrospective, hospital-based cross-sectional study. With a 92.5% response rate (250 participants), it examined how common ventilator-associated pneumonia (VAP) is in the PICU and the factors that contribute to it.

The prevalence of VAP was 16.8% (95% CI: 12.4–22%).
Globally, VAP rates vary depending on hospital type, infection control practices, and healthcare infrastructure. A study by the International Nosocomial Infection Control Consortium (INICC) found higher rates in academic and lower-middle-income hospitals than in wealthier settings [29]. For example, Egypt reported 31.8 cases per 1,000 ventilator-days and a prevalence of 36.2% [20, 30]. In contrast, studies in high-income countries like the US and Germany show lower VAP rates [32–34]. However, a European multicenter study still reported a 23.6% prevalence among children in PICUs [35].
These differences may be due to variations in infection control, staffing, and access to equipment. Our relatively high VAP rate may reflect challenges in resource availability and inconsistent application of VAP prevention bundles.

In our study, male patients had a significantly higher chance of developing VAP (OR = 9.6, 95% CI: 2.1–43.4, p = 0.003). This supports findings from a systematic review and studies in the UK and other countries that identified male sex as a VAP risk factor (OR = 1.50) [40, 42, 43].

However, a Spanish study reported higher in-hospital mortality in females after VAP, despite their lower incidence (OR = 1.24) [41]. Our study did not measure patient outcomes.

Generally, infants are at higher risk of VAP due to immature immunity, smaller airways, and prematurity [38]. However, in our study, children aged 28 days to 5 years did not show a significantly higher risk (p-values > 0.05), and nearly half of the VAP cases occurred in children over five years.

Admission diagnoses, such as acute respiratory failure (OR = 0.05, p = 0.12) or coma (OR = 0.026, p = 0.07), and comorbidities (OR = 0.10, p = 0.78), were not significantly associated with VAP. This contrasts with previous research, which links these conditions to higher VAP risk [44]. This difference may be due to variations in timing of VAP onset or the influence of other factors like ventilation duration and infection control.

Prolonged mechanical ventilation was a strong risk factor. Each additional day increased VAP odds by 16.5% (OR = 1.165, 95% CI: 1.113–1.219, p < 0.0001). A study in Indonesia also showed increased VAP risk with each additional day (AOR = 7.52, 95% CI: 2.26–25, p = 0.001) and with reintubation within 72 hours (AOR = 4.06, 95% CI: 1.36–12.09, p = 0.009). An Indian study found similar results in children ventilated for more than 4 days (AOR = 3.76, 95% CI: 1.41–10.02, p = 0.008) [44, 45].

Other significant risk factors included bronchoscopy (OR = 14.6, p = 0.011), nasogastric tube use with enteral feeding (OR = 12.2, p = 0.03), and patient transport out of the ICU (OR = 16.17, p = 0.004). These may increase aspiration or disrupt airway defenses.

Conversely, tracheostomy was protective (OR = 0.003, p = 0.005), possibly due to better airway control and less reintubation.

Continuous IV sedation was linked to higher VAP risk (OR = 5.8, p = 0.02), likely due to reduced airway protection. Previous studies also recommend minimal sedation to prevent VAP.

Proton pump inhibitor (PPI) use did not significantly affect VAP risk (OR = 1.83, p = 0.4), despite suggestions that altering stomach pH might promote bacterial colonization. This may be due to differences in dosing or infection control practices.

Most importantly, compliance with VAP prevention protocols strongly reduced the risk (OR = 0.005, p = 0.001). Effective practices include head-of-bed elevation, regular oral hygiene, and

avoiding unnecessary movement. These findings support global evidence emphasizing the importance of standardized infection control in reducing VAP [1, 7, 14].

7. Limitations of the study

Although this study provides useful information, it does have some limitations. Its single-center, cross sectional design limits the ability to establish causal relationships. Additionally, the findings may not be applicable to other PICU settings, emphasizing the need for larger, multicentre studies to validate these results. Future research should also look into longitudinal approaches to assessing the long-term effects of VAP, as well as the impact of specific changes to ventilation and care protocols on VAP incidence and patient mortality.

Additionally, incomplete records for some variables were produced by shortcomings in hospital data management and patient data registration systems, which might have impacted the analysis's thoroughness. Addressing these challenges in future studies could enhance data accuracy and reliability.

8. Conclusion

The magnitude of VAP in our PICU is consistent with other studies, indicating comparable rates in similar healthcare settings. Male sex and prolonged mechanical ventilation were significant risk factors for VAP, as observed in other studies. Bronchoscopy and NGT feeding were identified as risk factors, while tracheostomy was protective. Contrary to previous studies, age did not show a significant association with VAP, and children older than five years accounted for nearly half of the cases. Primary indication for mechanical ventilation, comorbidity, and origin of ICU admission did not show a significant association with VAP. Continuous intravenous sedation increased the risk of VAP, likely due to impaired airway reflexes and increased aspiration risk. Patient transportation out of the ICU also predisposed to VAP development Adherence to VAP prevention protocols, such as hand hygiene, oral care, and head-of-bed elevation, significantly decreased VAP incidence.

Despite resource limitations, adherence to VAP prevention protocols plays a critical role in minimizing VAP and improving outcomes

9. Recommendations

Based on this study, we recommend strengthening the use of ventilator-associated pneumonia (VAP) prevention bundles in our PICU. Applying these measures consistently can reduce the risk of infection in patients on mechanical ventilation.

We also suggest minimizing the length of mechanical ventilation whenever possible. Early weaning and daily assessment of readiness to extubate are important steps to help prevent VAP.

To support future research, we recommend improving medical record-keeping and data management. During this study, many patient files were incomplete, which made it harder to collect data accurately.

Lastly, we encourage future studies to use a prospective design and include patient outcomes. This will help us better understand how VAP affects recovery and guide more effective interventions..

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Annex I: Checklists

Questionnaire

Instructions for Respondents

- Please ensure all fields are filled out accurately.
- If a question does not apply, mark "N/A."
- For multiple-choice questions, select all that apply.
- Provide specific details where required.

Part I. Characteristics of patients with ventilator-associated pneumonia

1. SEX
A. Male
B. Female

2. Age

A. < 1yr **B**. 1-5yrs **C**. > 5yrs

3. Presence of VAP

A. Yes

B. No

4. Duration of mechanical ventilation___ (days)

5. Onset of VAP after intubation___(days)

6. Admitted to ICU from
A. pediatrics wards
B. Emergency OPD
C. Operative room

7. **Causative microorganism___**

8. Primary indication for mechanical ventilation
A. Acute respiratory failure
B. Coma or impaired consciousness
C. Neuro-muscular diseases (GBS, myasthenia gravis….)

9. Causes of ICU admission

A. Trauma
B. respiratory disease
C. Neurologic disorder
D. Cardiovascular disorder
E. intra-abdominal disorder (GI)
F. Poisoning (usually attempted suicide), or intoxications
G. Metabolic or renal
H. Others

10. Presence of Co-morbidity
A. SAM
B. Diabetes
C. Immunocompromised
D. Chronic kidney disease
E. Presence of malignancy
(Cancer)
G. Others

Part II - Potential Risk Factors

NO.	**RISK FACTORS**	**YES**	**NO**

1.	**Tracheostomy**		
2.	**Bronchoscopy**		
3.	**Re-intubation**		
4.	**Aspiration of gastric content**		
5.	**NGT and enteral feeding**		
6.	**Transportation out of the hospital (ICU) after intubation**		
7.	**Use of steroids**		
8.	**use of proton pump inhibitor (PPI)**		
9.	**Paralytic agents, continuous intravenous sedation**		
10.	**(1) compliance with the VAP bundle (elevation of bed to 20-30°),mouth care using chlorhexidine or tooth brushing, Maintenance of safe endotracheal tube cuff pressure)**		

11.	**Surgical drainage(mainly thoracic)or thoraco-abdominal surgery**		

12. Length of stay in the ICU _____ (days)

Annex II: Declaration form

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in this or any other university and that all sources of materials used for the thesis have been fully acknowledged.

Name: _____

Signature: _____

Name of the institution: _____

Date of submission: _____

This thesis has been submitted for examination with my approval of university advisor.

Name and Signature of the advisor _____

Name and Signature of the internal examiner

_____