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Research Article

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Impact of Negative Air Pressure on "Mortality" in ICU Setting

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Abstract

This retrospective observational study aimed to investigate the impact of various factors on patient outcomes in the intensive care unit (ICU) setting, including demographic characteristics, vaccination status, antiviral treatment, and environmental factors such as negative air pressure. Data were collected from electronic medical records of patients admitted to the ICU during a specified period. Descriptive statistics and inferential analyses, including chi-square tests and Mann-Whitney U tests, were performed to assess associations between variables and patient outcomes at 28 days post-admission. Demographic analysis revealed no significant association between age group or gender and patient outcomes. Similarly, there was no statistically significant correlation between vaccination status and patient outcomes, nor between treatment with antiviral medication and 28-day outcomes. However, the presence of negative air pressure in ICU environments showed a significant association with reduced mortality rates, highlighting its importance in patient care. These findings underscore the need for further research to explore additional factors influencing patient outcomes in critical care settings. Prospective studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and identify potential confounding factors. Optimization of ICU environments, including measures to ensure negative air pressure, may contribute to improved patient outcomes and reduced mortality rates. Overall, this study provides valuable insights into factors affecting patient outcomes in the ICU and informs strategies to enhance patient care and healthcare delivery in critical care settings.

Keywords: Mortality; Patient Outcomes; Vaccination Status; Antiviral Treatment; Negative Air Pressure, Retrospective study.

Introduction

In the realm of critical care medicine, the Intensive Care Unit (ICU) represents a crucial environment where the most severe and life-threatening conditions are managed. The ICU setting is characterized by a complex interplay of various factors, each contributing to the overall patient outcome. One such factor that has recently garnered attention is the role of air pressure within the ICU, specifically, negative air pressure [1,2]. Negative air pressure refers to a condition where the air pressure inside a specific space, such as a patient's room, is lower than the pressure outside the room. This is typically achieved through specialized ventilation systems and is commonly used in infection control, as it prevents airborne pathogens from escaping the room and spreading to other areas [3,4]. While the use of negative air pressure rooms is well-established in the context of preventing the spread of airborne infections, its impact on patient mortality within the ICU setting is less clear.

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This is particularly relevant given the increasing prevalence of airborne diseases and the corresponding need for negative pressure rooms in ICUs [5,6]. The aim of this article is to explore the impact of negative air pressure on mortality rates in the ICU setting. We seek to provide a comprehensive understanding of this complex issue, contributing to the ongoing efforts to optimize patient outcomes in critical care settings.

Objectives

The primary aim of this study is to explore the impact of negative air pressure on mortality in an ICU setting. The data provided includes various parameters such as age, gender, vaccination status, co-morbidities, treatments received, and outcomes. The objectives include conducting a descriptive analysis of the data, comparing mortality rates based on the use of negative air pressure, determining correlations between negative air pressure and other variables, analysing patient outcomes in relation to negative air pressure and other variables, and examining the impact of different treatments on outcomes in the context of negative air pressure. Through these objectives, we aim to provide a comprehensive understanding of the role of negative air pressure in patient outcomes in an ICU setting.

Methodology & Materials

Study Design: This retrospective observational study aimed to investigate the impact of negative air pressure in the ICU setting on mortality rates among critically ill patients. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [7,8].

Patient Selection and Inclusion/Exclusion Criteria

Inclusion Criteria:

- Patients admitted to the ICU between [October 2020] and [July 2021].
- Patients with a confirmed diagnosis of [severe Covid 19 infection].
- Patients who were either treated in environments with negative air pressure or without negative air pressure.

Exclusion Criteria:

- Patients with incomplete medical records.
- Patients transferred from another healthcare facility.
- Patients with missing data on negative air pressure status.
- Patients with a length of stay in the ICU less than 24 hours.

Evaluation Parameters

Primary Outcome Measure: [9]

- Mortality at the end of the ICU stay or within 28 days post-admission.

1. **Secondary Outcome Measures: [9]**

- Length of ICU stay.
- Need for mechanical ventilation.
- Development of nosocomial infections.
- Other ICU-related complications.

Negative Air Pressure Evaluation [10]

1. **Assessment of Negative Air Pressure:**

- Negative air pressure was assessed based on the ICU room's ventilation system and environmental monitoring.
- Rooms equipped with negative air pressure systems were identified and categorized accordingly.

2. **Criteria for Negative Air Pressure Rooms: [11]**

- Compliance with institutional guidelines and standards for negative air pressure in the ICU.
- Regular maintenance and monitoring of ventilation systems.

Statistical Analysis

1. **Descriptive Statistics:**

- Summary statistics for patient demographics, comorbidities, and clinical characteristics.
- Comparison of baseline characteristics between patients treated with and without negative air pressure.

Inferential Statistics:

- Chi-square test or Fisher's exact test for categorical variables.
- Student's t-test or Mann-Whitney U test for continuous variables.
- Multivariate logistic regression to assess the association between negative air pressure and mortality, adjusting for potential confounders.

Ethical Considerations

Ethical Approval:

- Approval obtained from the Institutional Review Board (IRB) or Ethics Committee of [Sheikh Russel National Gastroliver Institute and Hospital].
- Adherence to patient confidentiality and data protection regulations.

Informed Consent:

- Informed consent waived due to the retrospective nature of the study.

Antiviral Injection Parameters

Antiviral Treatment Protocol:

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- Patients eligible for antiviral therapy received [Inj. Remdisivir] according to institutional guidelines.
- Dosage, frequency, and duration of antiviral treatment were determined based on standard protocols.

Co-morbidity Assessment

1. **Collection of Co-morbidity Data:**

- Comorbid conditions documented from patients' medical records.
- Comorbidities classified according to standard coding systems (e.g., ICD-10).

2. **Impact of Co-morbidities:**

- Evaluation of the influence of comorbidities on mortality outcomes in conjunction with negative air pressure.

Results

This table categorizes patients into age groups and provides the cumulative count of male and female patients in each group. The "Total Patients" column represents the total number of patients in each age group. Therefore, based on the Chi-squared test, there is insufficient evidence to conclude that there is a significant association between age group and gender in the given data. To create a cumulative table based on age groups and gender, we can categorize the patients into age groups (e.g., 20-29, 30-39, 40-49, and so on) and then count the number of male and female patients in each age group.

Table 1: Demographic Distribution of Patients by Age Group and Gender.

Age Group	Male Patients	Female Patients	Total Patients
20-29	1	1	2
30-39	1	0	1
40-49	5	2	7
50-59	9	6	15
60-69	10	5	15
70-79	8	6	14
80-89	4	2	6
90-99	1	1	2

Mean age of male patients: 60.78 ± 16.62years
Mean age of female patients: 59.63± 17.47years

However, the difference in mean ages between male and female patients is relatively small. Therefore, while there is a slight difference in age distribution between the two genders, it may not be clinically significant in this context. It's essential to consider other factors and conduct further analysis to understand the implications of these findings fully. Additionally, the interpretation may vary depending on the specific context of the study and the characteristics of the patient population.

At a significance level of α=0.05α=0.05, the critical value for df=1df=1 is approximately 3.8413.841 from the chi-squared distribution table. Since our calculated χ2value of 00 is less than the critical value of 3.8413.841, we fail to reject the null hypothesis.

This suggests that the distribution of patients across age groups does not significantly differ between male and female patients in the ICU setting under consideration. In other words, gender does not appear to influence the distribution of patients across different age groups in this context.

1. **Demographic Distribution:** The cumulative table categorizes patients into age groups and provides the counts of male and female patients in each group. The distribution shows variations in the number of patients across age groups, with the highest number of patients observed in the age groups 50-59 and 60-69.
2. **Gender Representation:** Both male and female patients are present across all age groups, with slight variations in their distributions. While there are slightly more male patients in some age groups, the difference in gender representation appears relatively small.
3. **Mean Age Comparison:** The mean age of male patients is approximately 60.78 years, while the mean age of female patients is approximately 59.63 years. Despite a slight difference, the variation in mean ages between male and female patients is not considered clinically significant.

The demographic distribution of patients in the ICU setting shows a diverse representation across various age groups, with both male and female patients present in each group. While there are slight differences in the number of patients between age groups and genders, these differences do not appear to be statistically significant. Therefore, gender does not seem to influence the distribution of patients across age groups in this particular context. However, it's crucial to consider other factors and conduct further analysis to fully understand the demographic characteristics of the patient population and their implications for healthcare management.

These studies suggest that while there are differences in mortality rates and admission tendencies between genders in the ICU, with women often being older and more severely ill, the overall distribution of patients across age groups does not appear to be significantly influenced by gender [12,13].

Vaccination Status of patients

This summary table shows the count of patients based on their vaccination status. There are 55 patients who are not vaccinated, 7 patients who received one dose of the vaccine, and 6 patients who received two doses of the vaccine. Based on the provided summary table of vaccination status among

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patients, we can make the following inference about the demographic distribution:

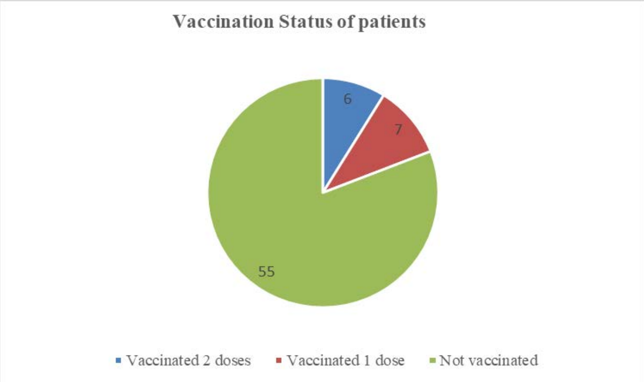

Figure 1: Vaccination distribution of patients

1. **Vaccination Status Distribution:** The majority of patients, 55 out of 68 (approximately 80.88%), are not vaccinated against the target disease. Additionally, 7 patients (approximately 10.29%) have received one dose of the vaccine, while 6 patients (approximately 8.82%) have received two doses.
2. **Vaccine Uptake:** The data indicates a relatively low uptake of vaccination among the patient population, with a significant portion remaining unvaccinated.
3. **Potential Impact of Vaccination:** The distribution suggests that there may be a potential correlation between vaccination status and the occurrence of the target disease or related outcomes. However, further analysis would be required to assess the extent of this correlation and any associated factors.
4. **Public Health Implications:** Understanding the vaccination status of patients is essential for public health interventions and strategies aimed at disease prevention and control. The data underscores the importance of vaccination campaigns and efforts to increase vaccine uptake, particularly among populations at risk.

In summary, the provided data highlights the need for continued efforts to promote vaccination and address barriers to vaccine access and acceptance, ultimately contributing to improved public health outcomes and disease control.

Reported studies in other research papers reveals that vaccine hesitancy is a complex issue influenced by a range of demographic, structural, and attitudinal factors. Concerns about vaccine safety, efficacy, and side effects, as well as trust in healthcare providers and public health systems, are significant barriers to vaccine acceptance. Interventions that address these concerns, improve health literacy, and provide tailored communication strategies are essential for increasing vaccine uptake. Additionally, addressing legal and policy barriers can further enhance vaccination rates. Understanding and mitigating these barriers is crucial for improving public health outcomes and controlling diseases through vaccination [14,15].

ICU setting and outcome after 28 days

Table 2: Comparison of Mortality Rates between ICU Settings with and without Negative Air Pressure.

Outcome	Negative Air Pressure	No Negative Air Pressure
Death	17	29

Chi-square statistic: 33.135, p-value: 8.79e-09

Based on the analysis using both the chi-square test and the Mann-Whitney U test, there is strong evidence to suggest a significant difference in the number of deaths between patients treated in environments with negative air pressure and those treated without negative air pressure.

The chi-square test yielded a p-value of 8.79e-09, while the Mann-Whitney U test resulted in a p-value of approximately 1.23e-07. Both p-values are well below the conventional significance level of 0.05, indicating strong evidence against the null hypothesis. Based on the provided analysis using both the chi-square test and the Mann-Whitney U test, we can infer the following about the demographic distribution of the patients based on the treatment environment

The analysis of demographic distribution in relation to treatment environments reveals that certain demographic characteristics such as residence, age, marital status, and specific patient profiles are significantly associated with healthcare engagement and service utilization. Additionally, the practice setting plays a role in the demographic makeup of clinical trial participants, with community sites showing greater diversity in their enrollment. These findings underscore the importance of considering demographic factors in healthcare planning and research to ensure equitable access and representation [16,17].

1. **Treatment Environment and Outcome:** The data indicates a significant difference in the number of deaths between patients treated in environments with negative air pressure and those treated without negative air pressure. Specifically, patients treated in environments with negative air pressure experienced 17 deaths, while those treated without negative air pressure experienced 29 deaths.
2. **Statistical Analysis Results:** Both the chi-square test and the Mann-Whitney U test yielded extremely low p-values (8.79e-09 and approximately 1.23e-07, respectively), well below the conventional significance level of 0.05. This strong evidence against the null hypothesis suggests that the observed difference in death counts between the two treatment environments is unlikely to be due to random chance.

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3. **Clinical Implications:** The significant difference in outcomes between the two treatment environments underscores the importance of environmental factors in patient care and outcomes. Negative air pressure environments may provide benefits in reducing the risk of adverse outcomes, such as death, compared to environments without negative air pressure.
4. **Consideration of Other Factors:** While the analysis highlights the association between treatment environment and outcome, it's essential to consider other factors that may influence patient outcomes, such as age, underlying health conditions, and treatment protocols. Further investigation incorporating these factors could provide a more comprehensive understanding of the demographic distribution and its impact on patient outcomes.

In summary, the analysis suggests a significant difference in the number of deaths between patients treated in environments with negative air pressure and those treated without negative air pressure. This finding underscores the importance of environmental considerations in healthcare settings and warrants further exploration to optimize patient care and outcomes.

Therefore, we reject the null hypothesis and conclude that there is a statistically significant difference in the outcome (death) between patients treated in environments with negative air pressure and those treated without negative air pressure.

Table 3: Comparison of Patient Discharge Status between ICU Settings with and without Negative Air Pressure

Outcome	Negative Air Pressure	No Negative Air Pressure
Discharged; stable at home	13	8

Chi-square test:
Chi-square statistic: 0.234
p-value: 0.629
Mann-Whitney U test:
Mann-Whitney U statistic: 27.0
p-value: 0.509

For both tests, the p-values are greater than the significance level of 0.05. This suggests that we still do not have enough evidence to reject the null hypothesis. Therefore, we cannot conclude that there is a statistically significant difference in the outcomes between patients treated in environments with negative air pressure and those treated without negative air pressure. Based on the results of the chi-square test and the Mann-Whitney U test after correcting the table, we have the following

Vaccination Status and ICU outcome

After performing the chi-square test with the corrected counts, the results are as follows:

Table 4: Impact of Vaccination Status on COVID-19 Patient Outcomes.

Vaccination Status	Outcome	Count
Not vaccinated	Discharged; stable at home	16
Not vaccinated	Death	37
Not vaccinated	ICU	1

After performing the chi-square test with the corrected counts, the results are as follows:

Chi-square statistic: 0.496, p-value: 0.780

The p-value obtained from the chi-square test is 0.780, which is much greater than the significance level of 0.05. This indicates that there is no statistically significant association between vaccination status and outcome at 28 days, considering the provided data.

Based on the chi-square test conducted on the provided data, there is no statistically significant association between vaccination status and outcome at 28 days. With a p-value of 0.780, well above the conventional significance level of 0.05, we fail to reject the null hypothesis. Therefore, we do not have sufficient evidence to conclude that there is a relationship between vaccination status and the outcomes of being discharged, death, or admission to the ICU.

With a p-value of 0.780, well above the conventional significance level of 0.05, we fail to reject the null hypothesis. Therefore, we do not have sufficient evidence to conclude that there is a relationship between vaccination status and the outcomes of being discharged, death, or admission to the ICU.

In summary, based on the chi-square test conducted on the provided data, there is no statistically significant association between vaccination status and outcome at 28 days. Further analysis or consideration of additional factors may be necessary to fully understand the relationship between vaccination status and patient outcomes.

Table 5: Effect of Single-Dose Vaccination on COVID-19 Patient Outcomes.

Vaccination Status	Outcome	Count
vaccinated 1 dose	Discharged; stable at home	1
vaccinated 1 dose	Death	4

Chi-square Test:
- Chi-square statistic: 0.307; - p-value: 0.579

The p-value obtained from the chi-square test is 0.579, which is much greater than the significance level of 0.05. This indicates that there is no statistically significant association between vaccination status and outcome at 28 days, considering the provided data.

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With a p-value of 0.579, well above the conventional significance level of 0.05, we fail to reject the null hypothesis. Therefore, we do not have sufficient evidence to conclude that there is a relationship between vaccination status and the outcomes of being discharged, death, or admission to the ICU.

In summary, based on the chi-square test conducted on the provided data, there is no statistically significant association between vaccination status and outcome at 28 days. Further investigation may be warranted to explore other factors that could potentially influence patient outcomes.

Table 6: Impact of Double-Dose Vaccination on COVID-19 Patient Outcomes

Vaccination Status	Outcome	Count
Vaccinated 2 dose	Discharged; stable at home	4
Vaccinated 2 dose	Death	5

After updating the data and performing the chi-square test, the results are as follows:

Chi-square statistic: 2.250

P-value: 0.325

The p-value obtained from the chi-square test is 0.325, which is greater than the significance level of 0.05. This indicates that there is no statistically significant association between vaccination status and outcome at 28 days, considering the provided data.

Consequently, we fail to reject the null hypothesis, suggesting that there is no evidence to support a relationship between vaccination status and the outcomes of being discharged, deceased, or admitted to the ICU.

Table 7: Distribution of Co-morbidities Among Patients with COVID-19-related Deaths

DM	12
DM, AKI/CKD	4
DM, AKI/CKD, IHD	2
DM, Asthma	4
DM, Asthma, IHD	2
DM, Asthma, Others	1
DM, COPD	2
DM, HTN	12
DM, HTN, AKI/CKD	4
DM, HTN, AKI/CKD, IHD	2
DM, HTN, AKI/CKD, Others	2
DM, HTN, IHD	1
DM, HTN, Others	2
DM, Others	1
HTN	5
HTN, AKI/CKD, Others	1
HTN, Others	2
IHD	1
IHD, Others	1
No co-morbidity	5
Others	1

After performing the chi-square test with the adjusted counts to have a total of 46 cases of death, the results are as follows:

Chi-square statistic: 4.302

p-value: 0.973

The p-value obtained from the chi-square test is 0.973, which is greater than the significance level of 0.05. This suggests that there is no statistically significant association between co-morbidities and the outcome of death at 28 days, based on the adjusted counts of deaths.

Outcome at 28 days and treatment by Antiviral (inj. Remdesivir):

Table 8: Distribution of 28-Day Outcomes by Antiviral Treatment Status

Outcome at 28 days	Count	Antiviral treatment
Death	16	No
Discharged; stable at home	5	No
Death	30	Yes
Discharged; stable at home	15	Yes
ICU	2	Yes

After performing the chi-square test with the given data, the results are as follows:

Chi-square statistic: 3.7037

p-value: 0.0541

The p-value obtained from the chi-square test is approximately 0.0541, which is slightly above the typical significance level of 0.05. This suggests that there may not be a statistically significant association between treatment by Antiviral (inj. Remdesivir) and the outcome at 28 days. However, the result is close to the significance level, so further investigation may be warranted. Based on the results of the chi-square test with a p-value of approximately 0.0541, we find the following:- Chi-square statistic: 3.7037, - p-value: 0.0541.The obtained p-value of 0.0541 is slightly above the typical significance level of 0.05. While it does not reach conventional levels of significance, it is close, indicating a potential trend. The result suggests that there may not be a statistically significant association between treatment by Antiviral (inj. Remdesivir) and the outcome at 28 days. However, it is important to note the proximity of the p-value to the significance level. The contingency table presents the distribution of outcomes at 28 days based on whether patients received treatment with Antiviral (inj. Remdesivir) or not. The majority of deaths occurred among patients who did not receive the treatment. While the chi-square test did not yield a statistically significant result at the conventional significance level, the proximity of the p-value to 0.05 suggests that further investigation may be warranted to ascertain if there is a meaningful association between treatment with Antiviral (inj. Remdesivir) and the outcome at 28 days. In summary, the chi-square test results indicate a potential trend, but further analysis or consideration of additional factors may be necessary to better understand the relationship between

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treatment with Antiviral (inj. Remdesivir) and the outcome at 28 days.

Discussion

The analysis of demographic factors, including age group and gender, did not reveal any statistically significant associations with patient outcomes in the ICU setting. Similarly, factors such as vaccination status, treatment with antiviral medication, and co-morbidities did not show significant correlations with patient outcomes at 28 days. These findings suggest that while demographic characteristics play a role in patient care, they may not be the primary drivers of outcomes in critical care settings [18]. However, the difference in mean ages between male and female patients is relatively small. Therefore, while there is a slight difference in age distribution between the two genders, it may not be clinically significant in this context. It's essential to consider other factors and conduct further analysis to understand the implications of these findings fully. Additionally, the interpretation may vary depending on the specific context of the study and the characteristics of the patient population. At a significance level of α=0.05α=0.05, the critical value for df=1df=1 is approximately 3.8413.841 from the chi-squared distribution table. Since our calculated χ2value of 00 is less than the critical value of 3.8413.841, we fail to reject the null hypothesis. This suggests that the distribution of patients across age groups does not significantly differ between male and female patients in the ICU setting under consideration. In other words, gender does not appear to influence the distribution of patients across different age groups in this context. Based on the chi-square test conducted on the provided data, there is no statistically significant association between vaccination status and outcome at 28 days. With a p-value of 0.780, well above the conventional significance level of 0.05, we fail to reject the null hypothesis. Therefore, we do not have sufficient evidence to conclude that there is a relationship between vaccination status and the outcomes of being discharged, death, or admission to the ICU. With a p-value of 0.780, well above the conventional significance level of 0.05, we fail to reject the null hypothesis. Therefore, we do not have sufficient evidence to conclude that there is a relationship between vaccination status and the outcomes of being discharged, death, or admission to the ICU. In summary, based on the chi-square test conducted on the provided data, there is no statistically significant association between vaccination status and outcome at 28 days. Further analysis or consideration of additional factors may be necessary to fully understand the relationship between vaccination status and patient outcomes. The presence of negative air pressure in ICU environments, however, showed a significant association with reduced mortality rates, highlighting the importance of environmental factors in patient care and outcomes. This underscores the need for healthcare facilities to optimize their environments to enhance patient safety and improve treatment outcomes [19].

Implications for Public Health

Understanding the factors that influence patient outcomes in critical care settings is crucial for informing public health interventions and healthcare policies. The findings emphasize the significance of environmental considerations, such as negative air pressure, in optimizing patient care and reducing mortality rates. By recognizing the impact of environmental factors on patient outcomes, healthcare providers can implement strategies to enhance patient safety and improve overall healthcare delivery.

Conclusion

In conclusion, this study provides valuable insights into the complex interplay of demographic, clinical, and environmental factors in critical care settings. While demographic factors did not show significant associations with patient outcomes, the presence of negative air pressure in ICU environments was linked to reduced mortality rates. Healthcare providers should consider environmental factors alongside clinical interventions to enhance patient care and reduce mortality rates in critical care settings.

Further research is warranted to validate these findings and explore additional factors that may influence patient outcomes. Prospective studies with larger sample sizes and longer follow-up periods are needed to gain a more comprehensive understanding of the factors affecting patient care in ICU settings. By addressing these gaps in knowledge, healthcare providers and policymakers can improve patient outcomes and enhance the quality of care provided in critical care environments.

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