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Clinical factors associated with the use of NIV in the pre-hospital setting in adult patients treated for acute COPD exacerbation: a single-center retrospective cohort study

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Abstract

Background Non-invasive ventilation (NIV) is a cornerstone in the management of acute chronic obstructive pulmonary disease (COPD) exacerbations with respiratory failure. While extensively studied in hospital settings, limited data exist on its use in the pre-hospital setting and clinical factors influencing its application. This study aimed to identify predictors of NIV use in the pre-hospital setting and to assess its association with patient-centered outcomes.

Methods This single-center retrospective cohort study analyzed data from a pre-hospital emergency medical service registry in Geneva, Switzerland. Adult patients with a presumptive diagnosis of acute COPD exacerbation were included, spanning a control period (2007–2010, before NIV implementation) and an intervention period (2013–2017, after NIV implementation). For the primary analysis, multivariable logistic regression was used to identify predictors of NIV use during the intervention period. For the secondary analysis, coarsened exact matching balanced patients treated with NIV during the intervention period with those from the control period, followed by conditional regression analyses to assess patient-centered outcomes.

Results Among 270 included patients, 84 (46%) received NIV during the intervention period. Age ≥ 70 years (aOR 2.49, 95% CI 1.11, 5.76), female sex (aOR 2.48, 95% CI 1.13, 5.60), and systolic blood pressure (SBP) ≥ 140 mmHg (aOR 2.75, 95% CI 1.19, 6.62) were independent predictors associated with receiving NIV in the pre-hospital setting. In the matched cohort, pre-hospital NIV use was significantly associated with increased ICU admission rates, but was not associated with transport time, emergency department length of stay, hospital length of stay, or 28-day mortality. Sensitivity analyses demonstrated consistent results across different modeling approaches.

Conclusions Age ≥ 70 years, female sex, and SBP ≥ 140 mmHg were independent predictors associated with receiving NIV in the pre-hospital management of acute COPD exacerbation. The association between NIV use and increased ICU admissions may reflect its application in more severely ill patients. Pre-hospital NIV was not associated with short- or long-term outcomes beyond ICU admission. These findings underscore the need for prospective studies to clarify the role of pre-hospital NIV in patient outcomes.

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Keywords Pulmonary disease, Chronic obstructive, Acute disease, Respiratory insufficiency, Ventilation, Noninvasive, Emergency medical services, Prehospital care

Background

Non-invasive ventilation (NIV) stands as a cornerstone in the management of acute chronic obstructive pulmonary disease (COPD) exacerbation with acute respiratory failure [1, 2]. However, only limited data exist regarding its use in the pre-hospital setting and the clinical factors that determine its utilization in this context.

COPD is a heterogeneous lung condition characterized by airflow obstruction that often progresses through acute exacerbations [3]. Diagnosis of acute COPD exacerbation relies upon clinical manifestations such as dyspnea, cough, and sputum production. Current in-hospital guidelines recommend a therapeutic regimen comprising inhaled bronchodilators, systemic corticosteroids, and antibiotics, with adjunctive NIV as the frontline intervention in cases complicated by acute respiratory failure [3, 4]. Studies have demonstrated that NIV improves gas exchange, reduces work of breathing, lowers the need for intubation, decreases hospital length of stay and mortality [5–8]. However, despite its benefits, NIV carries risks such as patient self-inflicted lung injury (P-SILI) and delayed intubation [9]. Admission to the intensive care unit (ICU) is frequent [10] and is associated with increased morbidity and mortality [11, 12].

Acute COPD exacerbation often requires emergency management, with a large proportion of patients receiving initial care from pre-hospital services prior to hospitalization [13]. In the pre-hospital setting, appropriate care is based on rapid clinical assessment and guided by structured algorithms centered on a presumptive diagnosis. Patients requiring NIV often present in a critical state, necessitating prompt intervention *en route* to the hospital. Although well-established in hospital protocols, its pre-hospital application poses challenges, as its initiation relies on clinical assessment given that advanced diagnostic tools are not always available to guide decision-making [14]. Additionally, the use of NIV can be complex and requires appropriate training [15, 16]. Finally, transport time may influence the choice of therapy as it is associated with mortality [17]. Little is known about the factors associated with its use, nor have objective parameters been thoroughly explored to predict the use of NIV in the pre-hospital setting.

The primary objective of this study is to identify clinically relevant factors associated with the use of NIV in the pre-hospital setting in adult patients with acute COPD exacerbation. Our secondary objective is to assess whether the implementation of NIV in this setting is associated with patient outcomes.

Methods

Data source and study population

This single-center, retrospective cohort study utilized data from the *Service Mobile d'Urgence et de Réanimation* (SMUR) registry, which includes all patients receiving pre-hospital care since the registry's inception in 2006. All adult patients (≥18 years) diagnosed with a presumptive acute COPD exacerbation at the scene were included. Patients were excluded if they (1) had a confounding respiratory diagnosis (e.g., congestive heart failure, acute asthma, upper airway obstruction, anaphylaxis, pulmonary embolism, or cardiac arrest), (2) were intubated without prior NIV initiation, or (3) were transported to a hospital other than the Geneva University Hospitals (HUG). In Geneva, patients with low-acuity conditions may be transported to smaller emergency departments within the city that lack the capability to provide advanced critical care or specialized respiratory support, including NIV. The inclusion period spanned from June 2007 to March 2010 (control period, when NIV was not available) and April 2013 to June 2017 (intervention period, when NIV was available). Patients treated between April 2010 and March 2013 were excluded to account for the transition phase of NIV implementation [18]. The study was approved by the Research Ethics Board of the Geneva University Hospitals in January 2019 (Project ID 2018–22–45). Progress was temporarily halted due to the COVID-19 pandemic, delaying the timeline for completing data analysis and manuscript preparation.

The city of Geneva, Switzerland, covering 282.5 km^2 with an estimated population of 524,379 in 2023 [19], is served by an emergency medical system composed of public and private ambulance services, including advanced life support ambulances staffed by certified paramedics. The system also includes a mobile emergency and resuscitation unit (SMUR) operated by the HUG. The SMUR team, consisting of an advanced paramedic and a physician specializing in anesthesia, emergency medicine, or internal medicine, is equipped with advanced airway management capabilities. It conducts over 5,000 missions annually as part of the HUG Emergency Department (ED), a tertiary urban teaching hospital admitting

over 65,000 patients each year. Responding to all pre-hospital life-threatening emergencies in the city, the SMUR operates under the supervision of a senior emergency physician available for dispatch 24/7. All emergency calls are handled by professional dispatchers, and both ambulance and SMUR are dispatched for acute respiratory distress cases.

Acute COPD exacerbation cases are managed according to established guidelines [3]. Before 2010, the management of acute respiratory failure in Geneva primarily involved oxygen therapy, with tracheal intubation reserved for more severe cases. Following the integration of the Hamilton T1 ventilator (Hamilton Medical, Bonaduz, Switzerland) into the SMUR in 2013, NIV became the standard of care for acute respiratory failure in suspected COPD exacerbations [14]. The decision to initiate NIV in the pre-hospital setting was not protocolized but rather left to the discretion of the treating physician [18]. This decision was guided by clinical evaluation and training provided to SMUR physicians and paramedics, emphasizing recognized indications for NIV use.

Exposure and outcomes of interest

For the primary objective, we sought to identify predictors of NIV use in the pre-hospital setting. We included eight clinically relevant exposure variables based on literature review and clinical expertise: age, sex, pulse oximetry (SpO_2) [20], respiratory rate (RR) [20], systolic blood pressure (SBP) [21], heart rate (HR) [21], Glasgow coma scale (GCS) [22], and transport time [23]. To apply these variables to the clinical setting, the following variables were dichotomized using recognized clinical thresholds: age (<70 vs. ≥ 70 years) [24], SpO_2 ($<90\%$ vs. $\geq 90\%$) [3], RR (<24 vs. ≥ 24 breaths/min) [3], SBP (<140 vs. ≥ 140 mmHg) [3, 25], HR (<95 vs. ≥ 95 beats/min) [3], GCS (<9 vs. ≥ 9) [26], and transport time (<15 vs. ≥ 15 min) [23]. Data were collected upon SMUR team arrival at the scene, as these represent the earliest measurements available to guide immediate management. The primary outcome was the use of NIV during the intervention period.

For the secondary objective, we sought to assess whether the implementation of NIV in the pre-hospital setting in Geneva, where transport times are relatively short, is associated with patient-centered outcomes. The exposure was the use of NIV, and secondary outcomes included transport time to the hospital, ED length of stay, hospital length of stay, ICU admission rates, and 28-day mortality. Transport time was measured from on-site departure to hospital arrival (in minutes), ED length of stay from admission to discharge (in hours), and hospital length of stay from hospital admission to discharge (in days).

Statistical analysis

Baseline variables were summarized using descriptive statistics for the overall population and stratified by NIV use. Continuous variables were presented as median and interquartile range (IQR), and categorical variables as counts and percentages (%).

To identify independent predictors of NIV use, we conducted multivariable logistic regression using data from the intervention period, when NIV was available. All eight exposure variables were included in the model. Results are expressed as adjusted odds ratios (aOR) with 95% confidence intervals (CI).

For the secondary analysis, coarsened exact matching (CEM) was applied to balance covariates between patients who received NIV during the intervention period, when NIV was available, and all patients from the control period, when NIV was not available. CEM was selected for its ability to reduce covariate imbalance and statistical model dependence, enabling a more robust comparison between the groups [27]. We matched patients based on variables associated to clinical severity and immediate outcomes, including on-site quick Sequential Organ Failure Assessment (qSOFA) score (continuous variable), age (<70 vs. ≥ 70 years) [24], and SpO_2 ($<90\%$ vs. $\geq 90\%$) [3]. Independent predictors of NIV identified in the primary analysis were then incorporated into the matching model. This final matching model provided a balanced comparison between groups, which was then used in conditional multivariable regression models. The regression models adjusted for these matching variables to assess the association between pre-hospital NIV use and secondary outcomes. The reason for adjusting on the variables used in the matching model was to address any residual imbalance and to help reduce variance and increase the precision of the estimates. Continuous outcomes, such as transport time, ED length of stay, and hospital length of stay, were analyzed as continuous variables, while ICU admission rates and 28-day mortality were treated as binary outcomes. For ICU admission rates, we also adjusted for the presence of advance directives that preclude ICU admissions and censored patients who died in the ED.

Sensitivity analyses

To assess the robustness of our findings, we conducted sensitivity analyses by testing the model's predictions using two different sets of confounders. First, we simplified the model to include only clinically relevant variables strongly associated with disease severity (qSOFA score, age, and SpO_2). These variables were selected based on their established role in reflecting acute illness severity and respiratory compromise,

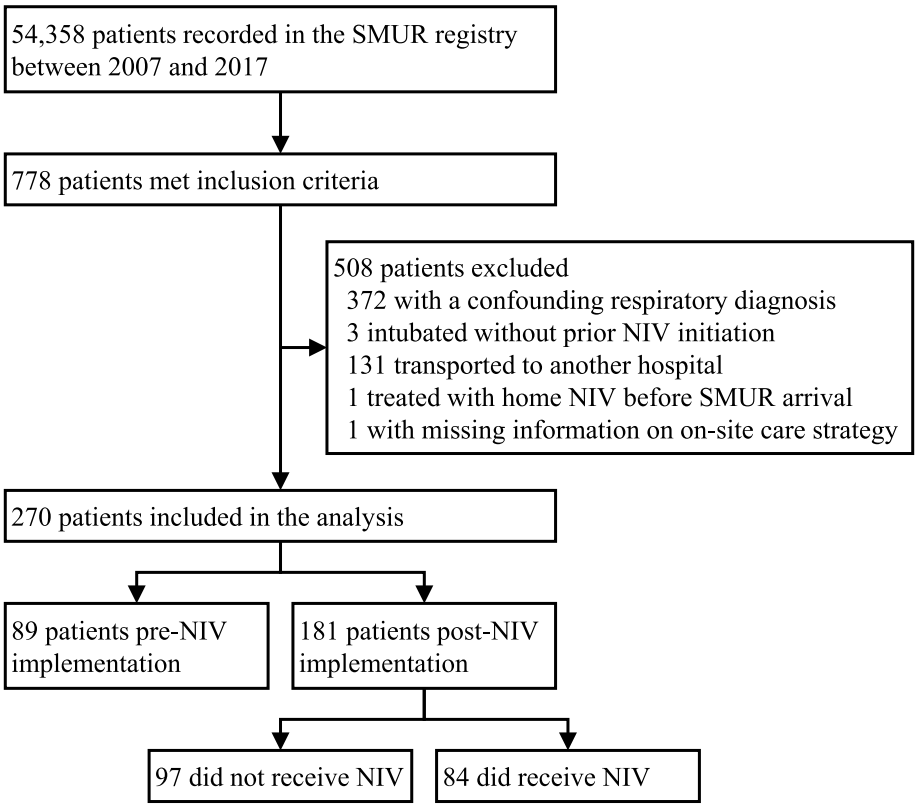

Fig. 1 Study flowchart. *SMUR, mobile emergency and resuscitation unit; NIV, non-invasive ventilation.* Among the 54,358 patients initially recorded in our registry, 270 were included in our analysis

particularly in patients with acute COPD exacerbation. This step allowed us to evaluate the performance of a model focused solely on key clinical indicators. We then reran the models incorporating all 8 variables (age, sex, SpO_2, RR, SBP, HR, GCS, and qSOFA), based on the premise that additional physiological and demographic factors could further refine predictions. Model performance was assessed using the area under the receiver operating characteristic curve (AUC) to evaluate discriminatory ability, the Brier Score to assess calibration, the McFadden's pseudo-R^2 to estimate model explanatory power, and the Akaike Information Criterion (AIC) to compare model fit while penalizing for complexity.

Our analysis utilized complete case data, assuming no systematic differences between included and missing cases. All analyses were performed using R version 4.4.2. A two-sided p-value < 0.05 was considered statistically significant. The study was conducted in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines [28].

Results

Out of 54,358 patients in the registry, 778 met the inclusion criteria for acute COPD exacerbation, of which 508 were excluded, resulting in 270 patients included in this study (Fig. 1). Of these, 89 patients were treated during the control period (when NIV was not available), and 181 patients during the intervention period (when NIV was available). Among the latter group, 84 (46%) were treated with NIV. The median age of the cohort was 72 years (IQR 63, 77), with 139 (51%) females. In the intervention period, patients receiving NIV were generally older, included a higher proportion of females, and presented worse vital signs compared to those not receiving NIV (Table 1). GCS scores remained consistently 15 across both groups. Patients receiving NIV had longer on-site treatment times but shorter transport times to the ED. Arterial blood pH was lower, and $PaCO_2$ was higher at ED admission in patients receiving NIV. During the control period, 1 patient was intubated upon arrival in the ED. In the intervention period, 10 patients required intubation in the ED, 5 of whom had received NIV in the prehospital setting. Among the 84 patients treated with NIV, 15 experienced issues during transport: 11 patients had NIV intolerance (no specific details provided), 1 patient

Table 1 Baseline characteristics of patients with acute COPD exacerbation during the intervention period, by NIV use

	Overall	Stratification by NIV		SMD
		no NIV used	NIV used	
	(*n* = 181)	(*n* = 97)	(*n* = 84)	
Baseline characteristics				
Age, years	72 (63, 76)	70 (62, 75)	72 (67, 77)	0.36
Female	101 (56%)	44 (45%)	57 (68%)	0.47
qSOFA score[1]				0.06
0	3 (2.3%)	1 (1.5%)	2 (3.3%)	-
1	111 (86%)	59 (87%)	52 (85%)	-
2	15 (12%)	8 (12%)	7 (11%)	-
Vital signs upon arrival on-site				
GCS score	15 (15, 15)	15 (15, 15)	15 (15, 15)	0.01
Hear rate, beats/min	112 (100, 123)	109 (97, 120)	115 (101, 127)	0.28
Systolic blood pressure, mmHg	150 (133, 170)	140 (129, 160)	156 (141, 176)	0.44
Respiratory rate, breaths/min	35 (28, 40)	32 (28, 39)	36 (32, 40)	0.47
SpO_2, %	88 (78, 95)	89 (80, 95)	88 (75, 94)	0.24
Timing and intubation				
Time on-site, min	24 (16, 30)	21 (14, 27)	27 (20, 32)	0.44
Transport time to the ED, min	16 (12, 20)	17 (13, 23)	15 (12, 19)	0.33
Orotracheal intubation	2 (1%)	2 (2%)	0 (0%)	-
Blood gases on ED admission[2]				
Arterial pH	7.35 (7.27, 7.40)	7.37 (7.31, 7.41)	7.32 (7.25, 7.36)	0.45
PaO_2, mmHg	9.6 (8.2, 13.0)	9.4 (7.9, 11.3)	9.9 (8.6, 13.9)	0.07
$PaCO_2$, mmHg	6.9 (5.8, 8.9)	6.2 (5.2, 8.3)	7.7 (6.6, 9.1)	0.3

Values are reported as medians (IQR) or counts (%)

COPD chronic obstructive pulmonary disease, *NIV* non-invasive ventilation, *SMD* standardized mean difference, *qSOFA* quick sequential organ failure assessment, *GCS* glasgow coma scale, *min* minute, *SpO_2*peripheral oxygen saturation, *ED* emergency department, *PaO_2* partial pressure of oxygen in arterial blood, *$PaCO_2$* partial pressure of carbon dioxide in arterial blood, *ABG* arterial blood gas

[1] There were no patients with a qSOFA of 3 in our cohort

[2] 142 patients (78%) had an ABG at ED admission

experienced interface problems and was intubated during transport, 1 patient showed deterioration in consciousness and was intubated on ED arrival, 1 patient exhibited respiratory muscle fatigue, and 1 patient had a non-functional NIV device.

Primary outcome

For our primary objective, age ≥ 70 years (aOR 2.49, 95% CI 1.11, 5.76), female sex (aOR 2.48, 95% CI 1.13, 5.60), and SBP ≥ 140 mmHg (aOR 2.75, 95% CI 1.19, 6.62) were all significantly associated with a higher odds of receiving NIV in the pre-hospital setting (Fig. 2, Supplementary Table S2). Results remained consistent after rerunning the model excluding GCS due to its lack of variability (Supplementary Table S3).

Secondary outcomes

We matched patients based on clinically relevant variables associated with disease severity (qSOFA score and SpO_2), as well as factors significantly associated with NIV use in the pre-hospital setting (age, sex, and SBP) (Fig. 3). Baseline characteristics of patients treated for acute COPD exacerbation, stratified by NIV availability, are presented in Supplementary Table S1. After CEM, multivariate regression analyses showed that NIV use in the pre-hospital settings was significantly associated with increased ICU admission rates (aOR 4.34, 95% CI 2.02, 18.32) (Table 2). However, it was not significantly associated with transport time to hospital, ED or hospital length of stay, or 28-day mortality.

Sensitivity analysis

When matching patients based on age, qSOFA score, and SpO_2, the use of NIV was significantly associated with an increase in both ICU admission rates (aOR 4.19, 95% CI 1.97, 10.97) and 28-day mortality (aOR 11.52, 95% CI 1.54, > 100) (Supplementary Table S5). However, when the full model with all 8 variables was used, the significant association was retained only for ICU admission rates (aOR 5.30, 95% CI 1.72, 10.94), with no significant

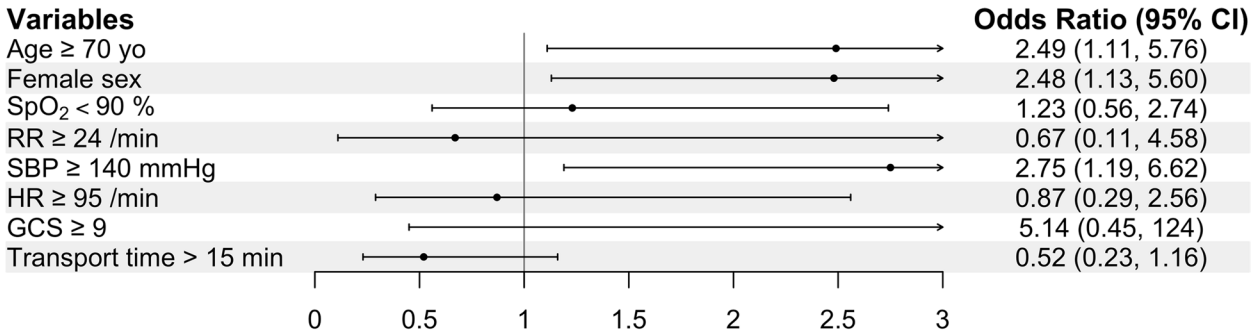

Fig. 2 Baseline variables associated with pre-hospital NIV use in acute COPD exacerbation. *NIV, non-invasive ventilation; COPD, chronic obstructive pulmonary disease; SpO_2, percentage of oxygen in the blood; RR, respiratory rate; SBP, systolic blood pressure; HR, heart rate; GCS, Glasgow coma scale; CI, confidence interval.* The forest plot presents the results of a multivariate logistic regression analysis to identify independent predictors of NIV use. *N* = 125

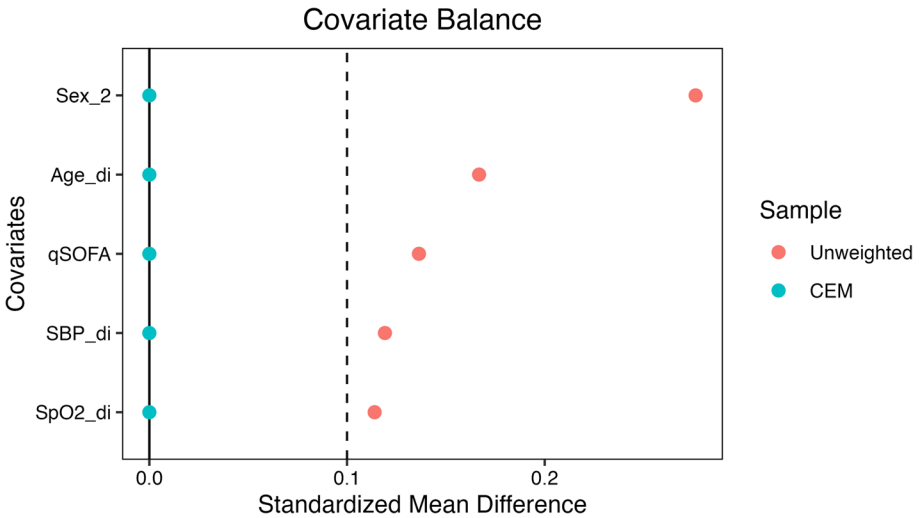

Fig. 3 Standardized mean differences before and after coarsened exact matching. *CEM, coarsened exact matching.* The LovePlot illustrates the standardized mean differences for covariates used in the matching process before and after coarsened exact matching (CEM), demonstrating the balance of covariates achieved with a threshold line at 0.1 indicating acceptable balance. After matching, 54 treated and 48 control patients were successfully matched

Table 2 Association of pre-hospital NIV use with patient outcomes in acute COPD exacerbation

Outcomes	β-coefficient	aOR	95% CI
Transport time to hospital	−0.12	-	−3.13, 2.40
ED length of stay	−0.57	-	−1.54, 0.47
Hospital length of stay	−1.48	-	−4.68, 1.32
ICU admission rates	-	4.34	2.02, 18.32
28-day mortality rates	-	7.18	0.63, > 100

This table presents the results of multivariate regression analyses after coarsened exact matching on age, sex, SpO_2, SBP, and qSOFA. The table assesses the association between the use of NIV in the pre-hospital setting and various patient outcomes

N = 124. 95% CI were calculated using 1′000 bootstraps

NIV non-invasive ventilation, *COPD* chronic obstructive pulmonary disease, *aOR* adjusted odds ratio, *CI* confidence interval, *ED* emergency department, *ICU* intensive care unit, SpO_2 peripheral oxygen saturation, *SBP* systolic blood pressure, *qSOFA* Quick Sequential Organ Failure Assessment

relationship observed for all other outcomes (Supplementary Table S6). Model performance showed that the 8-variable model consistently provided the best fit and discrimination for ICU admissions, while the simpler model with 3 variables demonstrated the strongest prediction for 28-day mortality. Overall, all models demonstrated low explanatory power.

Discussion

In this single-center, retrospective cohort study of patients treated for acute COPD exacerbation in the pre-hospital setting, we identified that age ≥ 70 years, female sex, and SBP ≥ 140 mmHg, were independent

predictors associated with higher odds of receiving NIV. The use of NIV was associated with increased ICU admission rates.

Despite its potential benefits, the use of NIV in the pre-hospital setting remains limited and is not yet considered standard of care globally. While adoption appears to be increasing in certain regions, such as Europe and Australia, the absence of clear international guidelines limits its widespread implementation [23, 29]. Our study provides critical insights by identifying clinically relevant factors associated with pre-hospital NIV use and examining its impact on patient-centered outcomes.

Little is known about the association between age and NIV initiation in the pre-hospital setting. Studies suggest that the intensity of care decreases with age, often influenced by patient or physician preferences to withhold more aggressive interventions like invasive mechanical ventilation (IMV) [30–32]. In the hospital setting, older patients (aged ≥ 75 years) experiencing acute COPD exacerbations are generally less likely to receive any form of mechanical ventilation, and when ventilated, they are more frequently managed with NIV rather than IMV, with no observed difference in NIV failure rates compared to younger patients [33]. However, mortality rates do not seem to differ, though older patients tend to require longer NIV durations and extended hospital stays [34]. While increased age in hospitalized COPD patients is associated with prolonged hospital stays and greater functional impairment, evidence on its association with long-term mortality remains conflicting [33, 35, 36]. In our study, the association between age (≥ 70 years) and a higher likelihood of receiving NIV may reflect a tendency in the pre-hospital setting to initiate NIV as a primary intervention for older patients who are less likely to undergo aggressive treatments once hospitalized. This approach could serve as an early strategy to stabilize respiratory distress in patients who might not be candidates for more invasive in-hospital care. Additionally, older patients are often more frail and sarcopenic, which can lead to reduced respiratory muscle strength and a limited capacity to manage acute COPD exacerbations, thereby necessitating immediate ventilatory support [37].

Sex differences have been reported to influence the effectiveness of continuous positive airway pressure (CPAP) on mortality, with CPAP being more effective in males; however, this difference has not been demonstrated with NIV [38]. Some studies suggest that male patients have a worse long-term prognosis following in-hospital NIV use for acute COPD exacerbation [39, 40]. In our study, female sex was associated with a higher odds of receiving NIV in the pre-hospital setting, potentially indicating that women are identified by the SMUR team as better candidates for NIV use.

No clear association between SBP and the use of NIV exists in the literature. Our findings suggest that the SMUR team may be cautious in applying positive pressure ventilation in patients with lower SBP, due to the potential hemodynamic effects. Positive pressure ventilation, including NIV, can reduce venous return and cardiac preload, leading to decreased cardiac output, which may cause or exacerbate hypotension [41–43]. In patients with already low SBP, this reduction in cardiac output could result in life-threatening hypotension.

The association between NIV use in the pre-hospital setting and increased ICU admission rates likely reflects the identification and targeted support of the most critically ill patients. However, the possibility of residual confounding cannot be excluded, despite efforts to adjust for relevant clinical variables through matching and regression models. NIV improves outcomes in COPD exacerbations by reducing work of breathing, enhancing gas exchange, and lowering intubation rates, morbidity, hospital length of stay, and mortality compared to standard oxygen therapy [2, 5, 44–46]. Evidence from the ED indicates that NIV trials in patients with acute respiratory failure of pulmonary origin, excluding those with recurrent aspiration pneumonia, can reduce in-hospital mortality and ICU stays [47]. Similarly, pre-hospital NIV has been shown to improve dyspnea and reduce stress-related adrenal discharge, potentially decreasing the need for intubation upon hospital arrival [38, 48–50]. In our study, the association between pre-hospital NIV use and increased ICU admissions may suggest that NIV serves as a marker of illness severity, effectively triaging patients who are more likely to require ICU-level care.

Patients receiving pre-hospital NIV may also be expedited to the ICU, as the SMUR team routinely informs ICU consultants when NIV is initiated, facilitating rapid ICU transfer upon ED arrival. However, we did not identify a significant association between pre-hospital NIV use and ED length of stay, neither with hospital length of stay or 28-day mortality. The lack of association with ED length of stay may be due to the relatively short overall ED times in our setting, minimizing a measurable impact. Similarly, no association with hospital length of stay or 28-day mortality could indicate that while NIV aids in stabilizing patients acutely, pre-hospital NIV on its own may not alter the broader course of disease severity or post-discharge outcomes, which are likely influenced by complex, multi-system factors beyond the scope of immediate respiratory support. Despite Geneva's relatively short transport times, the use of NIV did not appear to affect transport time to the hospital. Studies have shown that early pre-hospital NIV improves respiratory rate, dyspnea, and gas exchange, even during brief transport times (≤ 15 min) [23, 48]. Our findings support

the use of pre-hospital NIV for all patients with COPD exacerbation, as it does not seem to influence transport times to the hospital.

Our study has several strengths. First, the use of real-world data allows for a comparison of patient outcomes before and after the implementation of pre-hospital NIV. CEM serves as a robust matching tool to reduce covariate imbalance and model dependence, creating well-balanced groups and strengthening the observed associations. Our results remained consistent across multiple sensitivity analyses, further reinforcing the reliability of the associations. Finally, this study is among the first to explore clinical factors associated with pre-hospital NIV use, contributing valuable insights in a field where data collection is often rare and challenging.

Our study also has limitations. Like other balancing methods, CEM assumes exchangeability, relying on the inclusion of all relevant confounders. Although we addressed confounding in the design phase and achieved consistent results across sensitivity analyses, unmeasured confounders remain a potential limitation. Additionally, the study's single-center design and relatively small sample size may restrict the generalizability of our findings. Dichotomizing variables reduces variability and results in a loss of information; however, this approach aligns with real-world decision-making, where thresholds are essential for pre-hospital algorithms. Finally, while our models demonstrated low explanatory power, the consistency of results across models supports the credibility of our findings.

Conclusions

Age ≥ 70 years, female sex, and SBP ≥ 140 mmHg were independent predictors associated with receiving NIV in the pre-hospital management of acute COPD exacerbation. NIV use was associated with increased ICU admission rates, suggesting that pre-hospital NIV may act as a marker of illness severity, prompting expedited ICU referral. However, pre-hospital NIV was not associated with ED length of stay, hospital length of stay, or 28-day mortality. These findings address a critical gap in the literature and can inform the development of evidence-based protocols. They also provide a foundation for future prospective studies to validate and expand upon this work, ultimately guiding more effective and standardized use of NIV in emergency medical services. Further research is warranted to clarify the impact of these clinical predictors of NIV use on patient outcomes.

Abbreviations

AIC	Akaike Information Criterion
aOR	Adjusted Odds Ratios
AUC	Area Under the receiver operating characteristic Curve
CEM	Coarsened Exact Matching
CI	Confidence Intervals
COPD	Chronic Obstructive Pulmonary Disease
CPAP	Continuous Positive Airway Pressure
ED	Emergency Department
GCS	Glasgow Coma Scale
HR	Heart Rate
HUG	Geneva University Hospitals
ICU	Intensive Care Unit
IMV	Invasive Mechanical Ventilation
IQR	Interquartile Range
NIV	Non-Invasive Ventilation
qSOFA	Quick Sequential Organ Failure Assessment
SBP	Systolic Blood Pressure
SMUR	*Service Mobile d'Urgence et de Réanimation*
SpO_2	Peripheral oxygen saturation
RR	Respiratory Rate

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12873-025-01193-0.

Additional file 1.

Acknowledgements
Not applicable

Authors' contributions
BC, SvD, LS and CF designed and planned the study. BC conducted the data collection. SvD conducted the statistical analysis, and CF supervised the analysis. All authors interpreted the data. SvD and CF wrote the initial manuscript draft, and all authors were involved in critical revision of the final manuscript.

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Data availability
All data generated or analyzed during this study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study has received approval from the Research Ethics Board of the Geneva University Hospitals in January 2019 (Project ID 2018–22-45), with a waiver of written informed consent. All data were collected without personal identity information.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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