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Article

Impact of Underlying Chronic Medical Conditions on COVID-19 Outcomes among People Living with HIV: A Retrospective Analysis from the Minnesota Fairview Network

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Abstract: (1) Background: The COVID-19 pandemic has raised concerns about the impact of underlying medical conditions on the health outcomes of people living with HIV (PLWH). This study aimed to assess how pre-existing chronic medical conditions affect the health outcomes of PLWH infected with COVID-19. (2) Methods: A retrospective study using data from the Minnesota Fairview network (January 1, 2020 - December 31, 2022) was conducted. Fisher's Exact Test, Kruskal-Wallis rank sum test, and ordinal logistic regressions with Benjamini-Hochberg (BH) adjustment on p-values were used to assess the influence of chronic conditions on COVID-19 severity, adjusting for age and gender. (3) Results: Among 216 records, significant associations were found for stroke, chronic kidney disease, lung disease, and neurologic conditions ($p < 0.05$). Type 1 diabetes was marginally significant ($0.05 < p < 0.1$). After adjusting for age and sex, stroke ($p = 0.0008$, BH-adjusted $p = 0.0044$) and chronic kidney disease ($p = 0.0003$, BH-adjusted $p = 0.0033$) significantly increased the risk of severe COVID-19 outcomes. (4) Conclusions: Pre-existing medical conditions should be considered in the clinical management and public health interventions for PLWH with COVID-19. Tailored strategies are essential to mitigate the higher risk of severe outcomes in PLWH with specific chronic comorbidities.

Keywords: COVID-19 severity; comorbidities; people living with HIV; stroke; chronic kidney disease

1. Introduction

The Human Immunodeficiency Virus (HIV) infection has a dramatic and historically significant origin, akin to many major viral discoveries in medical history. First identified in 1983 through the cloning and sequencing of its genome, HIV was recognized as the causative agent of acquired immunodeficiency syndrome (AIDS) [1–4]. Since that pivotal discovery, the virus has spread globally, impacting millions of individuals across various demographics and regions. In the United States alone, approximately 1.2 million people are currently living with HIV (PLWH), with an

estimated 31,800 new infections reported in 2022 [5,6]. Although trends in HIV incidence have shown a decline over the past 40 years, the virus remains a formidable public health challenge that continues to necessitate attention and action [7].

HIV is not only associated with direct health effects but also complicates the management of a range of associated health issues, particularly for individuals who have pre-existing medical conditions [8]. The presence of such comorbidities can significantly lead to poorer health outcomes for those living with HIV, emphasizing the urgent need for comprehensive management strategies that take these underlying issues into account. Researchers have been working diligently to enhance HIV management, aiming to empower individuals living with the virus to lead fulfilling and productive lives despite their diagnosis [9].

The emergence of the Coronavirus 2019 (COVID-19) pandemic has further complicated this landscape. For individuals living with HIV, particularly those who also have chronic medical conditions, COVID-19 poses heightened risks and challenges [10]. The intersection of these two public health crises raises crucial questions about how comorbidities influence health outcomes for PLWH. As healthcare professionals adapt treatment approaches during the COVID-19 and HIV infection dual pandemic, it becomes increasingly important to understand the implications of these underlying medical conditions on overall health and well-being [11,12].

This study aims to assess the impact of chronic medical conditions on the health outcomes of PLWH who are also infected with COVID-19. By examining this population, the research seeks to provide valuable insights into how comorbidities affect disease progression and recovery in the context of both HIV and COVID-19. Understanding these dynamics is essential for informing best practices and improving the standard of care for individuals facing the dual challenges of HIV and COVID-19. Ultimately, the findings could lead to better-targeted interventions and support systems that enhance the quality of life for those navigating the complexities of these intertwined health issues.

2. Materials and Methods

Data was obtained from the Minnesota Fairview network via electronic health records (EHR) using a templated chart. This dataset included demographic information and clinical diagnoses of various chronic diseases. We focused on patients living with HIV who tested positive for COVID-19 via nasal swab and received care within the Minnesota Fairview network between January 1, 2020, and December 31, 2022, as described in previously published work by Aremu et al (2023) where the same dataset was used [10]. Patients with incomplete data were excluded from the analysis.

Our primary outcome was the severity of COVID-19, classified into four levels: (1) tested positive for COVID-19 without additional records, (2) admitted to the hospital due to COVID-19, (3) admitted to the ICU due to COVID-19, and (4) death possibly related to COVID-19. The exposure variables examined included chronic diseases identified by the CDC, such as heart disease, stroke, cancer, diabetes, cognitive impairment, as well as lung complications and chronic kidney disease (CKD) [13].

Descriptive statistics were computed to summarize baseline patient characteristics and chronic comorbidities across the four groups based on the severity of COVID-19: tested positive without additional records, hospitalized, admitted to the ICU, and those who died possibly related to COVID-19. We categorized chronic diseases defined by the CDC and generated additional aggregations. For instance, diabetes status included both Type 1 and Type 2 diabetes, while lung disease encompassed conditions such as chronic obstructive pulmonary disease (COPD), asthma, cystic fibrosis, and other lung disorders.

To compare baseline characteristics and chronic disease statuses among the four severity groups, continuous variables were summarized using means and standard deviations, while categorical variables were expressed as counts and percentages. The Kruskal-Wallis rank sum test was employed for continuous variables, and Fisher's Exact test was used for categorical variables. We fitted an ordinal regression model for each chronic disease and aggregation, adjusting for age and sex, to evaluate the impact of chronic comorbidities on COVID-19 severity. Additionally, a Benjamini-

Hochberg (BH) adjustment was applied to account for multiple comparisons. Significance level (alpha) was established at 0.05, and data analyses were carried out using R software, version 4.2.1.

This study adhered to the principles of the Declaration of Helsinki and received approval from the Institutional Review Board at the University of Minnesota as an exempt human research study (IRB ID: STUDY00013254).

3. Results

3.1. Patient Cohort and Severity Groups

A total of 216 patients with HIV who tested positive for COVID-19 were included in the analysis. The cohort was categorized into four groups based on the severity of their COVID-19 condition: those without additional records (N = 161), those admitted to the hospital (N = 42), those admitted to the ICU (N = 9), and those who died from COVID-19 (N = 4).

3.2. Baseline Characteristics

Table 1 summarizes the baseline characteristics of the patients. The median age across all groups did not vary significantly, with those admitted to the hospital, ICU, and deceased having a median age of 54, 60, and 49, respectively (p = 0.7). The age range across groups spanned from 41 to 65 years. Gender distribution revealed that males were the majority in each severity category, accounting for 67.6% of the patient cohort overall and 100% of the deceased group (p = 0.3).

Table 1. Baseline Patient Characteristics for COVID-19 Specific Mortality.

	Without Additional Records, N = 161	Admitted to Hospital, N = 42	Admitted to ICU, N = 9	Death COVID-19, N = 4	p-value
Age	54 (44, 61)	54 (41, 65)	60 (48, 63)	49 (49, 49)	0.7
Sex					0.3
Female	54 (34%)	15 (36%)	1 (11%)	0 (0%)	
Male	107 (66%)	27 (64%)	8 (89%)	4 (100%)	
Type 1 Diabetes					0.065
No	157 (98%)	37 (88%)	9 (100%)	4 (100%)	
Yes	4 (2.5%)	5 (12%)	0 (0%)	0 (0%)	
Type 2 Diabetes					0.3
No	128 (80%)	33 (79%)	5 (56%)	4 (100%)	
Yes	33 (20%)	9 (21%)	4 (44%)	0 (0%)	
Any Diabetes					0.3
No	128 (80%)	32 (76%)	5 (56%)	4 (100%)	
Yes	33 (20%)	10 (24%)	4 (44%)	0 (0%)	
Hypertension					0.3
No	74 (46%)	17 (40%)	2 (22%)	3 (75%)	
Yes	87 (54%)	25 (60%)	7 (78%)	1 (25%)	
Stroke					<0.001
No	156 (97%)	40 (95%)	5 (56%)	3 (75%)	
Yes	5 (3.1%)	2 (4.8%)	4 (44%)	1 (25%)	
Cancer					0.4
No	148 (92%)	37 (88%)	9 (100%)	3 (75%)	
Yes	13 (8.1%)	5 (12%)	0 (0%)	1 (25%)	
Chronic Kidney Disease					0.001
No	135 (84%)	26 (62%)	4 (44%)	3 (75%)	
Yes	26 (16%)	16 (38%)	5 (56%)	1 (25%)	

COPD					0.6
No	145 (90%)	37 (88%)	7 (78%)	4 (100%)	
Yes	16 (9.9%)	5 (12%)	2 (22%)	0 (0%)	
Asthma					0.9
No	140 (87%)	37 (88%)	9 (100%)	4 (100%)	
Yes	21 (13%)	5 (12%)	0 (0%)	0 (0%)	
Cystic Fibrosis					0.4
No	160 (99%)	41 (98%)	9 (100%)	4 (100%)	
Yes	1 (0.6%)	1 (2.4%)	0 (0%)	0 (0%)	
Other lung Disease					<0.001
No	155 (96%)	34 (81%)	6 (67%)	3 (75%)	
Yes	6 (3.7%)	8 (19%)	3 (33%)	1 (25%)	
Any Lung Disease					0.3
No	126 (78%)	29 (69%)	5 (56%)	3 (75%)	
Yes	35 (22%)	13 (31%)	4 (44%)	1 (25%)	
Neurologic Condition					0.035
No	152 (94%)	38 (90%)	9 (100%)	2 (50%)	
Yes	9 (5.6%)	4 (9.5%)	0 (0%)	2 (50%)	
Heart Condition					0.2
No	130 (81%)	29 (69%)	6 (67%)	3 (75%)	
Yes	31 (19%)	13 (31%)	3 (33%)	1 (25%)	

Regarding comorbidities, certain chronic conditions were more prevalent among patients with severe outcomes. Stroke showed a statistically significant association with worse outcomes, particularly among ICU patients (44%) and those who died (25%), with a p-value of <0.001. Chronic kidney disease (CKD) also showed a significant association with COVID-19 severity, affecting 56% of ICU patients and 25% of those who died ($p = 0.001$). Other conditions, such as hypertension and cancer, were not statistically significant ($p = 0.3$ and $p = 0.4$, respectively). The presence of diabetes, whether Type 1 or Type 2, did not show significant variation across groups.

3.3. Multivariate Analysis

Table 2 outlines the odds ratios (ORs) from multivariate logistic regression models for various chronic conditions in relation to COVID-19 mortality.

Table 2. Summary of Models, death being COVID-19 specific.

Model	Odds Ratio	95% CI	p-value	adjusted p-value
Pulmonary Conditions				
Age	0.9986	0.9783, 1.0198	0.8971	
Sex: Male vs Female	1.3902	0.7172, 2.7942	0.3398	
Pulmonary Conditions: Yes vs No	1.8205	0.9140, 3.5607	0.0828	0.2048
All Chronic Disease				
Age	0.9954	0.974, 1.0176	0.6790	
Sex: Male vs Female	1.2882	0.6677, 2.5696	0.4591	
All Chronic Disease: Yes vs no	1.6996	0.8061, 3.7858	0.1760	0.2766
Any Type Diabetes				
Age	0.9995	0.9791, 1.0207	0.9586	
Sex: Male vs Female	1.3150	0.6836, 2.6177	0.4216	
Any Type Diabetes: Yes vs no	1.3250	0.6287, 2.6936	0.4456	0.5888
Type 1 Diabetes				

Model	Odds Ratio	95% CI	p-value	adjusted p-value
Age	1.0003	0.9801, 1.0213	0.9798	
Sex: Male vs Female	1.3183	0.683, 2.6338	0.4198	
Type 1 Diabetes: Yes vs no	2.8073	0.7887, 9.2146	0.0931	0.2048
Type 2 Diabetes				
Age	0.9999	0.9796, 1.0212	0.9957	
Sex: Male vs Female	1.3188	0.6858, 2.6244	0.4166	
Type 2 Diabetes: Yes vs no	1.2139	0.5665, 2.4925	0.6057	0.6057
Hypertension				
Age	0.9979	0.9761, 1.0206	0.8539	
Sex: Male vs Female	1.2924	0.6695, 2.5798	0.4537	
Hypertension: Yes vs no	1.2556	0.6397, 2.5013	0.5112	0.5888
Stroke				
Age	0.9909	0.9702, 1.0123	0.3973	
Sex: Male vs Female	1.2514	0.6447, 2.5097	0.5157	
Stroke: Yes vs no	8.5864	2.4098, 30.7546	0.0008	0.0044
Cancer				
Age	0.9999	0.9795, 1.0211	0.9914	
Sex: Male vs Female	1.3361	0.6941, 2.6616	0.3956	
Cancer: Yes vs no	1.3808	0.4633, 3.6831	0.5353	0.5888
CKD				
Age	0.9906	0.9698, 1.012	0.3838	
Sex: Male vs Female	1.2213	0.6235, 2.4668	0.5667	
CKD: Yes vs no	3.6544	1.8063, 7.4236	0.0003	0.0033
Neurologic Conditions				
Age	0.9967	0.9759, 1.0184	0.7631	
Sex: Male vs Female	1.3075	0.6777, 2.6095	0.4332	
Neurologic Conditions: Yes vs no	2.3019	0.709, 6.9595	0.1465	0.2686
Heart Conditions				
Age	0.9977	0.9772, 1.0189	0.8258	
Sex: Male vs Female	1.2787	0.6615, 2.5546	0.4734	
Heart Conditions: Yes vs no	1.8300	0.8985, 3.65	0.0895	0.2048

Age was not a significant predictor of mortality across all models. Similarly, sex was not a significant predictor of mortality in any model, with ORs ranging from 1.2514 to 1.3902 across the models.

Stroke emerged as a strong predictor of COVID-19-related death, with an OR of 8.5864 (95% CI: 2.4098, 30.7546; $p = 0.0008$; BH-adjusted $p = 0.0044$). In essence, the odds of having a more severe outcome for a patient with stroke is 8.5 times as much as a patient without stroke. Chronic kidney disease was also significantly associated with higher mortality (OR = 3.6544; 95% CI: 1.8063, 7.4236; $p = 0.0003$; BH-adjusted $p = 0.0033$). In essence, the odds of having a more severe outcome for a patient with CKD is 3.7 times a patient without CKD. After accounting for age and sex, chronic kidney disease and stroke remain to be significantly associated with COVID-19 severity. Other comorbidities, including neurologic conditions, heart conditions, and diabetes, did not show a statistically significant association with mortality after adjustment. While Type 1 diabetes showed a potential trend toward higher mortality (OR = 2.8073; $p = 0.0931$; BH-adjusted $p = 0.2048$), this association did not reach statistical significance.

4. Discussion

In this study, we identified key comorbidities associated with poor outcomes in COVID-19 patients, particularly among those living with HIV. Although age and sex did not emerge as significant predictors of mortality, the presence of stroke and chronic kidney disease (CKD) were

strongly associated with increased risks of poor COVID-19 outcomes, including in-hospital admission, ICU admission and death. These findings are consistent with prior research that underscores the elevated risk posed by pre-existing conditions such as cerebrovascular disease and CKD in the context of COVID-19 [14,15].

Stroke emerged as the most impactful predictor of severe COVID-19 outcomes, with an odds ratio (OR) of 8.5864. This significant association highlights the heightened vulnerability of patients with cerebrovascular disease, which may exacerbate the inflammatory response triggered by COVID-19. Similar to prior studies, our results emphasize the need for rigorous monitoring and management of stroke patients, particularly in the context of a viral infection like COVID-19 [16,17].

Chronic kidney disease (CKD) also demonstrated a strong association with severe outcomes, with an OR of 3.6544. CKD has been linked to worse outcomes in viral infections due to impaired renal function and the additional burden it places on the immune system. In line with previous research, the findings support the necessity for close renal monitoring and early intervention for patients with CKD during COVID-19 illness [18,19].

While diabetes and hypertension are frequently highlighted as risk factors for severe COVID-19 outcomes in the general population [14], these conditions did not reach statistical significance in our cohort after multivariable adjustment. This lack of significance suggests that in the presence of more critical comorbidities such as stroke and CKD, these conditions alone may not independently drive the severity of outcomes. This is in agreement with some recent studies that indicate the interplay of multiple comorbidities, rather than any single condition, may play a crucial role in determining outcomes [19].

Besides, despite the trends suggesting higher risks for patients with diabetes and heart conditions, our findings indicate that these factors may not uniformly increase mortality risk in HIV patients with COVID-19. This highlights the complexity of interactions between HIV status, chronic conditions, and viral infections, warranting further exploration [17].

These findings emphasize the importance of early identification and targeted clinical management for high-risk groups, particularly patients with stroke and CKD. Tailored interventions that address these comorbidities may mitigate the risk of severe outcomes in COVID-19 patients, including those living with HIV. Stroke and CKD, in particular, demand more attention, given their strong associations with increased mortality.

5. Conclusions

Our study emphasizes the critical role of pre-existing medical conditions in influencing COVID-19 outcomes among people living with HIV (PLWH). Specifically, chronic diseases such as stroke and chronic kidney disease (CKD) were found to significantly affect the severity and mortality associated with COVID-19 in this vulnerable population. These findings highlight the need for tailored clinical management strategies that address the unique risks faced by PLWH with specific chronic comorbidities.

By implementing targeted interventions, healthcare providers can mitigate the heightened risk of severe COVID-19 outcomes and improve overall health for individuals with HIV. Also, these insights are essential for guiding public health initiatives aimed at reducing mortality rates in high-risk groups. Future research should focus on exploring the cumulative effects of multiple chronic conditions and refining intervention strategies to enhance health outcomes for PLWH facing the challenges posed by COVID-19.

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Informed Consent Statement: Patient consent was waived because medical record data was only obtained in EPIC for patients that had opted in allow their deidentified record used for research.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy reasons.

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