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ORIGINAL ARTICLE

Determinants and mortality associated with renal dysfunction among SARS-CoV-2 infected patients at KCMC Referral Hospital, North-Eastern Tanzania

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ABSTRACT

Background: Renal dysfunction is a common manifestation of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and contributes to increased mortality. However, data on its determinants and associated mortality within Sub-Saharan Africa (SSA) remain limited.

Methods: This hospital-based retrospective cohort study analysed data for 504 patients with confirmed SARS-CoV-2 infection who were admitted at the Kilimanjaro Christian Medical Centre (KCMC) between 10th March 2020 and 26th January 2022. Data were extracted from electronic medical records and Stata v18 was used for data analysis. Logistic regression identified factors associated with renal dysfunction, and Cox regression analyzed mortality predictors.

Results: The mean age was 62.7 ± 17.4 years and 56.3% were males. The most common comorbidities were hypertension (48.8%) and diabetes mellitus (30.2%). The median serum creatinine was 96 µmol/L (IQR 73.5 - 141.5 µmol/L). Renal dysfunction was found in 215 (42.6%) patients. Confusion (65.5%) and severe COVID disease (48.7%) were the most common clinical presentations among those with renal dysfunction. Factors significantly associated with renal dysfunction included age over 60 years (AOR 2.11, 95% CI 1.09 – 4.07), male sex (AOR 1.56, 95% CI 1.07 – 2.67), and hypertension (AOR 1.51 ,95% CI 1.02 - 2.24). Mortality was more frequent among patients with renal dysfunction compared to those without (45% vs. 20%, P < 0.001). After adjustment, renal dysfunction (AHR 2.21, 95% (1.81 – 3.62), patients age over 60 years (AHR 4.00, 95% CI 1.92– 8.34) and COVID disease severity (AHR 4.29, 95% CI 2.04–9.02) were independently associated with mortality.

Conclusions: Renal dysfunction is prevalent in SARS-CoV-2 patients and is associated with older age, male sex, and hypertension. Mortality is high among these patients, particularly those aged over 60 years. These findings identify a high-risk group requiring prioritized care and further studies for targeted interventions.

Keywords: Determinants, Renal dysfunction, SARS-CoV-2, Tanzania.

INTRODUCTION

Since its emergence in December 2019, the global COVID-19 pandemic caused by the novel Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has significantly impacted global health, with 776,841,264 confirmed cases and 7,075,468 deaths reported worldwide as of November 2024 [1]. In Tanzania, 43,298 confirmed cases and 846 deaths were reported in the same period [1].

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SARS-CoV-2 infection presents with a broad spectrum of clinical manifestations, ranging from asymptomatic infection to critical illness. Common symptoms include cough, fever, dyspnea, fatigue, anosmia or ageusia, sore throat, headache, diarrhea, and myalgia [2]. While the respiratory system is the primary target, the virus can also affect the gastrointestinal, cardiovascular, nervous, and renal systems, contributing to disease severity and poor outcomes [3,4] One of the most common renal manifestations reported among patients with SARS-CoV-2 is renal dysfunction, defined by elevated serum creatinine levels that have been used as a surrogate marker for acute kidney injury [5].

The prevalence of renal dysfunction in patients with SARS-CoV-2 varies widely, ranging from 11.6% in China to 45.3% in the United Arab Emirates [6,7]. In Sub-Saharan Africa (SSA), renal dysfunction in Ethiopia was 90% among SARS-CoV-2 patients [8]. Multiple determinants of renal dysfunction levels among SARS-CoV-2 patients have been reported such as older age, male sex, disease severity, and hypoxia. Comorbidities such as hypertension, diabetes, coronary heart disease, chronic obstructive pulmonary disease have also been associated with an increased risk of renal dysfunction [9,10].

Furthermore, renal dysfunction in SARS-CoV-2 patients has been associated with a more than two-fold increased risk of death [11]. A systematic review of 15,536 patients revealed that 77.3% of those with elevated creatinine were critically ill [12]. Despite the global burden, there is limited data from SSA particularly Tanzania on the determinants of and mortality associated with renal dysfunction in SARS-CoV-2 infected patients. This study aimed to assess these factors among patients admitted to the Kilimanjaro Christian Medical Centre (KCMC), a referral hospital in northern Tanzania.

METHODS

We carried out a hospital-based retrospective cohort study of confirmed SARS-CoV-2 infected patients admitted to KCMC, one of the four zonal referral hospitals in Tanzania. The hospital serves patients from the Kilimanjaro region (its main catchment area), as well as nearby regions including Arusha, Tanga, and Manyara, along with other parts of Tanzania.

During the SARS-CoV-2 pandemic, suspected cases presenting to the Emergency Medicine Department were tested, and those with confirmed SARS-CoV-2 infection were admitted to a dedicated isolation ward for inpatient management. This study utilised data from the isolation ward database, which was maintained in Microsoft Excel and populated by physicians following patient assessments.

The database included information on demographic characteristics (age, sex, and region of residence); comorbidities; clinical symptoms and signs; COVID-19 wave period; serum creatinine levels at admission; disease severity as classified according to WHO criteria: mild (uncomplicated upper respiratory tract infection), moderate (pneumonia with no need for supplemental oxygen (O_2 saturation >93% on air), severe (fever or suspected respiratory infection, plus at least one of the following: respiratory rate >30 breaths per minute, severe respiratory distress, O_2 saturation ≤93% on air), and critical (acute respiratory failure, and/or shock); [13,14] and survival outcomes at discharge. We included all adult patients (aged ≥18 years) with confirmed SARS-CoV-2 infection who were admitted to the KCMC isolation ward between 10th March 2020 and 26th January 2022.

Out of 1,117 suspected SARS-CoV-2 cases during the study period, 570 were confirmed. Of these, 504 patients were included in the final analysis. We excluded patients with missing serum creatinine values and those with known end-stage renal disease (Figure 1).

The primary outcomes of this study were renal dysfunction and mortality. Renal dysfunction was defined as a serum creatinine level greater than 108 µmol/L for men and 97.24 µmol/L for women [15]. Mortality was defined as in-hospital death during the admission for SARS-CoV-2. Additionally, SARS-CoV-2 cases were categorised according to waves of infection: Wave 1, March to August 2020; Wave 2&3 were recorded from January to December 2021; Wave 4, December 2021 to January 2022.

Data were analysed using Stata version 18 (StataCorp LLC, College Station, TX, USA). Categorical variables were summarised as frequencies and percentages, while continuous variables were described using mean and standard deviation.

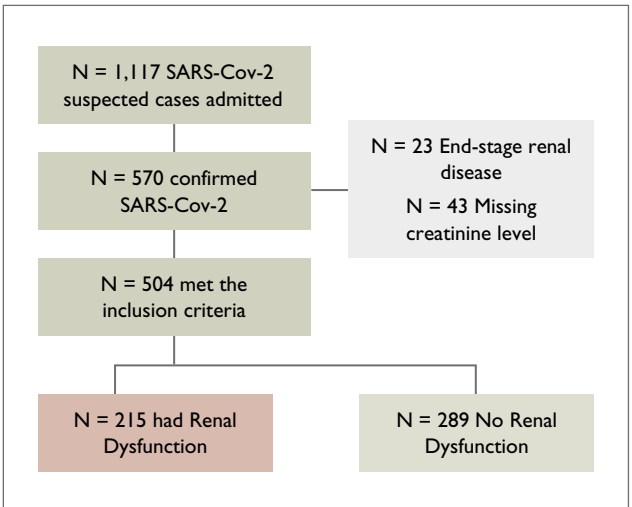

Figure 1. Flow chart showing patients with SARS-CoV-2 included in the study.

The Chi-square test was used to assess the difference in proportion of renal dysfunction by categorical variables. Logistic regression analysis was employed to identify factors associated with renal dysfunction. In the bivariate analysis, variables with a p value <0.05 and those deemed clinically relevant were considered for inclusion in the multivariable logistic regression model. A p value <0.05 was considered statistically significant in the final model.

To identify factors associated with mortality, crude cox regression analysis was initially performed. Variables with a p value <0.1 and those of clinical relevance were included in the multivariable Cox regression model. A p value <0.05 in the final model was considered statistically significant. The proportional hazards assumption was tested using the global Schoenfeld residuals test and was not violated.

Ethical approval for this study was obtained from the Kilimanjaro Christian Medical University College Research Ethics and Review Committee (CRERC), with certificate number 41/2021.

RESULTS

Patient background characteristics

Among 504 confirmed SARS-CoV-2 patients included in the analysis, the mean age was 62.7 ±17.4 years and 284 (56.3%) were males. The majority of the patients (452, 89.7%) were from the Kilimanjaro region. Hypertension was the most common comorbidity (246, 48.8%) followed by diabetes mellitus (152, 30.2%) (Table 1).

Distribution of renal dysfunction by clinical characteristics of SARS-CoV-2 patients

The median serum creatinine was 96 µmol/L (IQR 73.5 - 141.5 µmol/L). Renal dysfunction was present in 215 (42.6%) of patients with SARS-CoV-2. The most common clinical presentations were cough (392, 77.8%), shortness of breath (378, 75.0%), and fever (303, 60.1%). While the prevalence of most symptoms did not differ significantly between patients with and without renal dysfunction, confusion was notably more frequent in those with renal dysfunction (65.5% vs. 34.5%, P = 0.010). A higher proportion of severe COVID disease was observed among patients with renal dysfunction (48.7%) compared to those with moderate (41.8%) or mild (32.0%) COVID disease (P = 0.012) (Table 2).

Determinants of renal dysfunction among patients with SARS-CoV-2

In adjusted analysis, male sex had 56% higher odds of renal dysfunction compared to females (AOR 1.56, 95% CI 1.07 – 2.67, P = 0.021). Patients aged over 60 years had more than 2-fold increased odds of having renal dysfunction compared to those under 40 years (AOR 2.11, 95% CI 1.09 – 4.07, P = 0.026). Having hypertension was also significantly associated with renal dysfunction, increasing the odds by 51% (AOR 1.51, 95% CI: 1.02–2.24, P = 0.037) (Table 3).

Mortality among SARS-CoV-2 patients with renal dysfunction

A significant difference in mortality was observed between SARS-CoV-2 patients with renal dysfunction compared to those without renal dysfunction. Of the 215 SARS-CoV-2 patients with renal dysfunction, 96 (45%, P < 0.001) died. Deaths among SARS-CoV-2 patients with renal dysfunction increased across the pandemic waves from 11 (31%) during the first wave to 23 (66%) in the fourth wave (Figure 2). Compared by presence of renal dysfunction, the change in mortality across the waves was significant (P = 0.05).

After multivariable adjustment, age over 60 years remained strongly associated with mortality (AHR 4.00, 95% CI 1.92–8.34, P=0.001), as did severe disease severity (AHR 4.29, 95% CI 2.04–9.02, P=0.001). Patients with renal dysfunction had significantly higher risk of mortality compared to those with no renal dysfunction (AHR 2.21, 95% CI 1.81–3.62, P=0.023). Moderate disease severity (AHR 2.02, 95% CI 0.90–4.54, P=0.087) and confusion (AHR 1.76, 95%

Table 1. Background characteristics of SARS-CoV-2 patients in the study (N=504).

Characteristics	n (%)
Age group (SD)	
<40	55 (10.9)
40-59	138 (27.4)
≥60	311 (61.7)
Sex	
Female	220 (43.7)
Male	284 (56.3)
Region	
Arusha	44 (8.7)
Dar-es-salaam	4 (0.8)
Kilimanjaro	452 (89.7)
Manyara	2 (0.4)
Tanga	2 (0.4)
Comorbidities	
Hypertension	246 (48.8)
Diabetes Mellitus	152 (30.2)
Malignancy	25 (5.0)
Asthma	17 (3.4)
HIV	12 (2.4)
Neurological disease	13 (2.6)
Liver disease	6 (1.2)
SARS-CoV-2 waves	
Wave 1	89 (17.7)
Wave 2 & 3	346 (68.6)
Wave 4	69 (13.7)

Abbreviations: SD, Standard Deviation; HIV, Human Immunodeficiency Virus.

Table 2. Determinants of renal dysfunction among patients with SARS-CoV-2 (N=504).

Variable	Total, n (%)	Renal dysfunction		P value
		No, n (%)	Yes, n (%)	
SARS-CoV-2 symptoms				
Fever	303 (60.1)	180 (59.4)	123 (40.6)	0.250
Shortness of breath	378 (75.0)	212 (56.1)	166 (43.9)	0.323
Chest pain	238 (47.2)	134 (56.3)	104 (43.7)	0.656
Cough	392 (77.8)	227(57.9)	165 (42.1)	0.630
Runny nose	23 (4.6)	13 (56.5)	10 (43.5)	0.935
Loss of taste	66 (13.1)	43 (65.2)	23 (34.8)	0.169
Diarrhoea	40 (7.9)	24 (60.0)	16 (40.0)	0.723
Nausea/Vomiting	58 (11.5)	31 (53.5)	27 (46.5)	0.524
Abdominal pain	39 (7.9)	21 (53.9)	18 (46.1)	0.646
Headache	85 (16.9)	52 (62.7)	32 (37.3)	0.306
Confusion	29 (5.7)	10 (34.5)	19 (65.5)	0.010
Seizure (n=435)	10 (2.3)	6 (60.0)	4 (40.0)	0.929
Joint pain	60 (11.9)	33 (55.0)	27 (45.0)	0.696
Muscular pain	31 (6.1)	21 (67.7)	10 (32.3)	0.227
Oxygen saturation on air (n=452)				
<94	313 (69.2)	177(56.6)	136(43.4)	0.360
≥94	139(30.8)	85(61.1)	54(38.9)	
Disease severity[a]				
Mild	116(23.0)	79(68.0)	37(32.0)	0.012
Moderate	160(31.8)	93(58.1)	67(41.8)	
Severe	228(45.2)	117(51.3)	111(48.7)	

[a] As classified by the WHO; Mild: uncomplicated upper respiratory tract infection; Moderate: Pneumonia with no need for supplemental oxygen (o_2 sats >93% on air); Severe: Fever or suspected respiratory infections, plus one of the following: respiratory rate >30 bpm; severe respiratory distress; o_2 sat1.6(1.1-2.3)s ≤93% on air.

Table 3. Determinants of renal dysfunction among patients with SARS-CoV-2 (N=504).

Variable	Crude OR	P value	AOR	P value
Sex				
Female	1.53 (1.07-2.19)	0.020	1.56 (1.07-2.67)	0.021
Male	1.00 (Ref)		1.00 (Ref)	
Age				
<40	1.00 (Ref)		1.00 (Ref)	
40-59	1.33 (0.67-2.66)	0.414	1.28 (0.63-2.61)	0.493
60+	2.61 (1.39-4.92)	0.003	2.11 (1.09-4.07)	0.026
Diabetes mellitus (Yes)	1.72 (1.17-2.52)	0.006	1.46 (0.96-2.20)	0.075
Hypertension (Yes)	1.80 (1.26-2.57)	0.001	1.51 (1.02-2.24)	0.037
Asthma (Yes)	1.53 (0.58-4.04)	0.386		
HIV (Yes)	2.75 (0.82-9.27)	0.102		
Malignancy (Yes)	1.26 (0.56 – 2.80)	0.580		
Liver disease (Yes)	2.72 (0.49 – 14.90)	0.250		
Neurological disease (Yes)	0.84 (0.27 – 2.59)	0.757		
Disease severity				
Mild	1.54 (0.93 - 2.54)		1.38(0.83-2.32)	
Moderate	2.03 (1.27 – 3.23)	0.092	1.64(1.01-2.67)	0.217
Severe	1.00 (Ref)	0.003	1.00 (Ref)	0.05

Abbreviation: HIV, Human Immunodeficiency Virus; logistic regression model was used.

CI 0.91–3.39, P=0.091) were no longer statistically significant after adjustment. Age 40-59 years (AHR 1.84, 95% CI 0.83–4.08) and male sex (CHR 1.37, 95% CI 0.92–1.99) were not significantly associated with mortality in either analysis (Table 4).

DISCUSSION

This study found that renal dysfunction among patients with SARS-CoV-2 was significantly associated with older age, male sex, and hypertension. Older age, severe form of SARS-CoV-2 and renal dysfunction was found to be significantly associated with mortality. These findings underscore the importance of monitoring kidney function in SARS-CoV-2 patients.

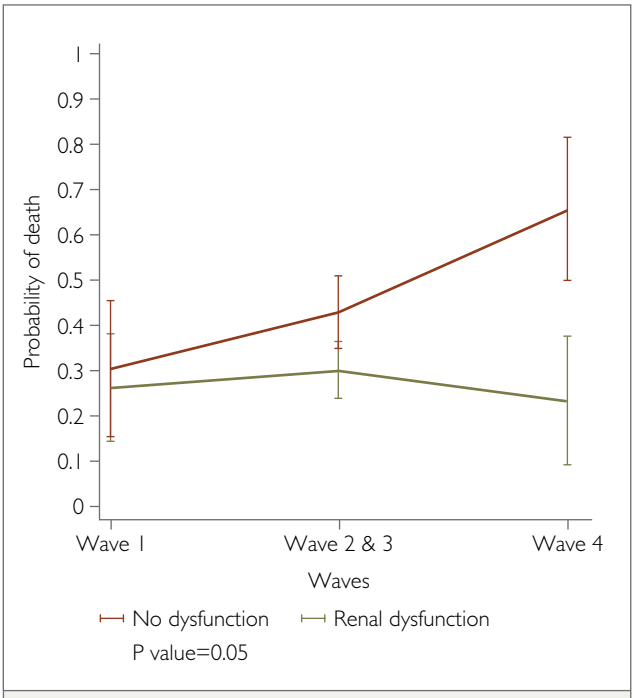

Figure 2. Probability of death among SARS-CoV-2 patients with renal dysfunction (N=504).

Patients with renal dysfunction in this study were more likely to present with severe SARS-CoV-2 disease. This finding aligns with a study from Iran, which reported that 77.8% of patients with severe SARS-CoV-2 had renal involvement [16]. One plausible explanation is that patients with a high viral load may experience increased renal invasion by the virus via the angiotensin-converting enzyme 2 (ACE2) receptor. Although ACE2 is predominantly expressed in lung tissue, it is also highly expressed in the kidneys [17]. Studies have detected SARS-CoV-2 RNA in glomerular cells and viral particles in kidney tissues and urine, supporting the hypothesis of direct viral invasion causing glomerular damage [18]. Postmortem studies have further shown acute tubular necrosis, endothelial damage, and complement-mediated tubular injury, suggesting that both direct cytopathic effects and immune-mediated mechanisms contribute to renal dysfunction. Other contributing factors include systemic inflammation, coagulation abnormalities, sepsis, hypoxemia, and nephrotoxic medications, which may result in tubulointerstitial, glomerular, and vascular injury [19,20]. These findings highlight the need for close renal monitoring and early intervention in patients with severe SARS-CoV-2 as it has been shown to improve patient outcomes [21,22].

We observed a higher likelihood of renal dysfunction in male patients, consistent with findings from studies conducted in the United States [23]. Gender-related differences in ACE2 and TMPRSS2 expression key receptors that facilitate viral entry may explain this disparity [18]. Males tend to express higher levels of these receptors, which may

Table 4. Factors associated with mortality among SARS-CoV-2 patients (N= 504).

Characteristic	Crude analysis		Adjusted analysis	P value
	CHR (95% CI)	P value	AHR (95% CI)	
Sex				
Female	1 (Ref)			
Male	1.37 (0.92 – 1.99)	0.120		
Age				
<40	1 (Ref)		1 (Ref)	
40-59	1.56 (0.71 – 3.41)	0.351	1.84 (0.83 – 4.08)	0.134
≥ 60+	5.00 (2.43 – 10.26)	0.001	4.00 (1.92 – 8.34)	0.001
Disease severity				
Mild	1 (Ref)		1 (Ref)	
Moderate	2.37 (1.08 – 5.22)	0.032	2.02 (0.90 – 4.54)	0.087
Severe	5.68 (2.77 - 11.66)	0.001	4.29 (2.04 – 9.02)	0.001
Renal dysfunction				
No renal dysfunction	1 (Ref)		1 (Ref)	
Renal dysfunction	1.64 (1.13 – 2.39)	0.010	2.21 (1.81 – 3.62)	0.023
Confusion				
No	1 (Ref)		1 (Ref)	
Yes	2.82(1.51 – 5.26)	0.001	1.76 (0.91 – 3.39)	0.091

enhance viral entry and tissue damage [24]. Additionally, androgens are thought to modulate immune responses by reducing antibody production and increasing inflammation, further exacerbating disease severity in males [25].

Older age was also significantly associated with renal dysfunction, which is in line with studies from Singapore and other settings [26]. Age related decline in kidney function is well established in general population, this includes structural and functional changes in the kidneys, including tubular atrophy and arteriosclerosis of small vessels, may predispose elderly patients to renal injury when exposed to acute stressors such as SARS-CoV-2 infection.

Hypertension was another significant risk factor for renal dysfunction in this cohort. This is supported by findings from Portugal and South Africa [21,22]. Chronic hypertension can lead to endothelial dysfunction, increased vascular permeability, and inflammatory changes in renal tissue, thereby compounding the risk of acute kidney injury in the context of SARS-CoV-2. However, the association between hypertension and renal dysfunction should be interpreted with caution, as some hypertensive patients may have had undiagnosed chronic kidney disease.

The overall mortality rate among patients with renal dysfunction was 45%, slightly lower than findings from South Africa, where a mortality rate of 58% was reported in this group [22]. This high mortality may be partially explained by the cytokine storm phenomenon, characterised by excessive release of pro-inflammatory cytokines in response to SARS-CoV-2 infection, which can contribute to multi-organ failure, including acute kidney injury [24].

The study also observed a progressive increase in mortality across the SARS-CoV-2 waves, with the highest death rate (66%) recorded during the fourth wave. This trend may be attributed to changes in SARS-CoV-2 strains over time, which have been associated with increased virulence, hospitalisation, and complications [25,27]. Additionally, during the pandemic, there was increased use of traditional herbal remedies in Tanzania. Some of these herbs have been associated with nephrotoxicity [28] and, although not directly assessed in this study, may have contributed to renal dysfunction and increased mortality. Further studies are warranted to explore the role of traditional medicine in renal outcomes during SARS-CoV-2 infection.

Older age was consistently associated with higher mortality in SARS-CoV-2 patients with renal dysfunction. Similar trends have been reported in studies from South Africa, the United States, and Portugal [21,23,29]. Age-related decline in immune function, increased systemic inflammation, and altered renin-angiotensin system activity may all contribute to increased vulnerability in this population. Changes in ACE2 expression and impaired immune responses in the elderly may exacerbate disease progression and increase the risk of death.

This study has several strengths. Firstly, it is the first study in Tanzania to assess the determinants and mortality among SARS-CoV-2 patients with renal dysfunction, thereby contributing important local evidence to the global understanding of SARS-CoV-2. Secondly, it includes data collected over a two-year period spanning four distinct waves of SARS-CoV-2 infection, allowing for comparative analysis across different phases of the pandemic.

However, the study also has some limitations. The reliance on hospital records may introduce information bias due to potential missing or incomplete data on key variables such as history of CKD and dialysis. Renal dysfunction was defined solely based on serum creatinine levels, which may not fully capture the complexity or severity of kidney impairment in this patient population. This study was conducted at a zonal referral hospital, limiting the generalisability of findings to the broader population, including primary care settings.

CONCLUSION

This study highlights the significant burden of renal dysfunction among patients with SARS-CoV-2 infection, particularly among older adults, males, and individuals with hypertension. The high mortality observed among patients with renal dysfunction, especially those aged over 60 years, identifies a high-risk population that warrants close monitoring. These findings provide a foundation for future studies to evaluate targeted management strategies. The high mortality observed among patients with renal involvement underscores the importance of integrating renal function monitoring into the clinical management of SARS-CoV-2, especially in high-risk populations. Additionally, potential contributors such as evolving viral strains and use of nephrotoxic traditional remedies warrant further investigation.

Acknowledgments

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Authors Contribution

S.N.L, N.G.C, and K.G.K were the principal investigators of the study, G.W, N.J contributed in the design of the study. S.N.L., M.M and L.J.S performed the analysis of the study, H.A, F.S. I.M, F.M, F.L, E.S, E.M, S.U participated in reviewing and editing the manuscript.

Conflict of interest

The authors have no conflicts of interest to declare.

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