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Mobile COVID-19 Screening Units: Heat Stress and Kidney Function Among Health Care Workers

To the Editor:

During the COVID-19 pandemic, mobile COVID-19 testing units were commonly used in many countries. Because health care workers (HCWs) were required to wear personal protective equipment (PPE) and work outdoors, heat stress became an emerging occupational hazard.[1] This study aimed to assess incident kidney injury in HCWs from heat stress in mobile COVID-19 testing units.

We applied a repeated measurement design to measure pre- and postshift kidney function and physiological changes in HCWs. The Research Ethics Committee of National Taiwan University approved the research protocol (No. 202106HN031). All participants provided written informed consent before the study. The study participants were recruited from a mobile COVID-19 screening unit in Taipei, Taiwan, that had been working on the screening bus for 3 months after the outbreak. We measured temperature and relative humidity inside the PPE by a Kestrel DROP D3 Temperature, Humidity & Pressure Logger (Nielsen-Kellerman Company)[2] and calculated the heat index for each work shift (Figs S1-S2; Item S1).[3] Physicians conducted face-to-face interviews and confirmed the medical history. We collected fingertip blood samples to measure whole blood creatinine and calculated the estimated glomerular filtration rate (eGFR) using the 2009 CKD-EPI creatinine equation.[4] We used 1 eGFR prior to work and 1 eGFR after work to calculate the cross-shift eGFR change (ΔeGFR; postshift value less preshift value). Incident kidney injury was defined as whole blood creatinine increase of >0.3 mg/dL or 1.5-fold.[5] Proteinuria was defined as protein excretion >30 mg/dL by dipstick. We also calculated the kinetic GFR (kGFR) to estimate incident kidney injury (Item S1).[6] We used a medical-grade infrared ear thermometer (RA600; Rossmax) to measure change in core body temperature. All participants sat for 5 minutes before their BP was taken while they were in a sitting position. We measured body weight while the participants were in a base layer of clothing. Postshift dehydration was defined as >1.5% body weight loss. We used a structured questionnaire to obtain occupational risk factors, including whether electrolytes were added to the drinking water, a habit of drinking sugary beverages, and whether drinking water was avoided before wearing PPE to prevent the desire to void. Paired sample *t* tests were used to test pre-and postshift measurements.

We recruited 50 HCWs (44 nurses and 6 bus drivers) from a mobile COVID-19 testing unit between September and October 2021. After exclusion of 5 participants to

Table 1. Demographic Characteristics and Pre- and Postshift Measurements

Demographic Characteristics	Nurses (n = 39)	Bus drivers (n = 6)
Age, y	30.4 ± 6.5	46.0 ± 7.8
Female sex	35 (90%)	0 (0%)
Current smoker	4 (10%)	1 (17%)
Height, cm	160.9 ± 6.1	176.2 ± 6.2
BMI, kg/m²	22.9 ± 4.0	26.4 ± 3.3
Work shift, min	120.8 ± 23.2	152.5 ± 30.6
Fluid intake, mL	641.3 ± 370.0	1,033.3 ± 752.8
kGFR, mL/min/1.73 m²	18.5 ± 33.9	73.3 ± 51.8

Pre- and Postshift Measurements	Nurses			Bus Drivers		
	Preshift	Postshift	*P*	Preshift	Postshift	*P*
Aural temperature, °C	36.4 ± 0.3	36.6 ± 0.3	<0.001	36.9 ± 0.4	36.5 ± 0.5	0.2
Body weight, kg	59.4 ± 10.5	59.2 ± 10.5	0.05	82.2 ± 13.6	82.1 ± 13.2	0.9
Systolic BP, mm Hg	111.9 ± 11.5	109.9 ± 9.4	0.3	141.5 ± 17.7	138.2 ± 19.4	0.6
Diastolic BP, mm Hg	75.9 ± 9.7	73.5 ± 9.2	0.2	90.0 ± 13.5	90.3 ± 14.7	0.9
Creatinine, mg/dL	0.8 ± 0.2	1.0 ± 0.2	<0.001	1.1 ± 0.2	1.1 ± 0.1	0.9
eGFR, mL/min/1.73 m²	104.6 ± 17.6	81.2 ± 17.8	<0.001	79.3 ± 9.4	80.0 ± 8.9	0.9
Urine specific gravity	1.012 ± 0.009	1.012 ± 0.008	0.9	1.005 ± 0.005	1.007 ± 0.003	0.3
Proteinuria	0 (0%)	4 (10%)		0 (0%)	0 (0%)	
Incident kidney injury	–	9 (23%)		–	0 (0%)	

Values for continuous variables given as mean ± SD. Abbreviations: BP, blood pressure; BMI, body mass index.

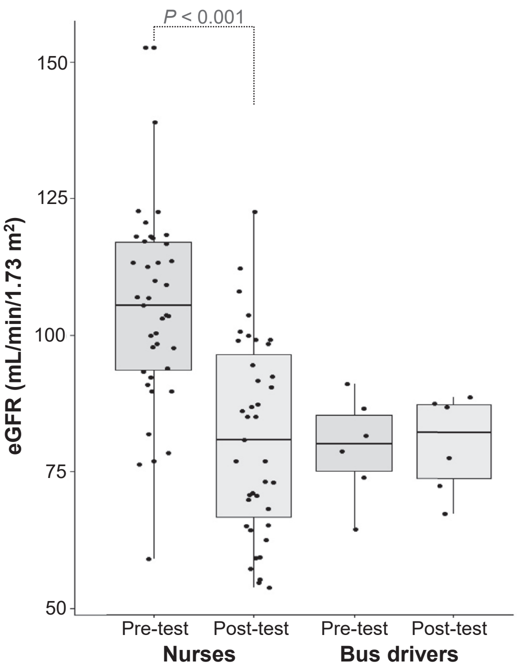

Figure 1. Pre- and postshift eGFR, by worker type. For nurses, median pre- and postshift eGFRs were 105.4 (IQR, 93.2-117.1) and 80.7 (IQR, 65.1-98.4) mL/min/1.73 m^2, respectively. For bus drivers, corresponding values were 80.1 (IQR, 71.5-87.6) and 82.1 (IQR, 71.1-87.6) mL/min/1.73 m^2. *P* values for cross-shift changes are by paired *t* test.

standardize blood collection procedures, 45 HCWs (39 nurses and 6 bus drivers) were included in the final analysis. In the nurses, there was a significant increase in core body temperature ($P < 0.001$) and nominal decreases in body weight ($P = 0.05$), systolic BP ($P = 0.3$), and diastolic BP ($P = 0.2$). Nine nurses (23%) developed incident kidney injury and 4 nurses (11%) developed proteinuria. Nurses had a significantly lower kGFR than bus drivers ($P = 0.001$) (Table 1). We observed a significant cross-shift eGFR decline in the nurses ($P < 0.001$) but not in the bus drivers ($P = 0.9$) (Fig 1). During the study period (September and October 2021), the environmental temperature was 29.3 ± 2.3 °C, with an ambient heat index of 35.0 ± 3.8 °C. The personal heat index was 46.8 ± 6.1 °C for nurse members and 48.4 ± 4.9 °C for nurse leaders (Fig S1). Large amounts of sweat and limited evaporation significantly increased humidity within the PPE, leading to higher heat stress (Fig S2). Direct sunlight exposure ($P = 0.03$) and avoiding drinking water ($P = 0.03$) increased the risks for kidney function decline in univariable analysis (Table S1).

To our knowledge, this is the first study that provides evidence that HCWs wearing PPE and working outdoors during hot weather have a significant decline in their kidney function. Although the association of sugary beverages with ΔeGFR observed in this study was of borderline statistical significance, an effect would be consistent with the mechanism of increased vascular resistance in the kidney reported by Chapman et al.[7] There are some limitations. First, this study used aural temperature as core body temperature, which is not as accurate as rectal temperature.[8] Second, this study did not measure urinary biomarkers of kidney injury, which could provide better insight into the mechanisms or location of kidney injury.[9]

We recommend that governments pay attention to the thermal hazard of kidney injury in HCWs during the COVID-19 pandemic.

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Supplementary Material

Supplementary File (PDF)

Figures S1-S2; Item S1; Table S1.

Article Information

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