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Experimental paper

The impact of different recovery positions on the perfusion of the lower forearm and comfort: A cross-over randomized controlled trial

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Abstract

Background: International guidelines recommend a side-lying recovery position for unresponsive individuals with normal breathing who do not require cardiopulmonary resuscitation. However, high-certainty evidence about an optimal recovery position is lacking. Recent guidelines recommend a position with the arm extended rather than bent, hypothesizing that venous drainage in the dependent lower arm might be compromised. This cross-over randomized controlled trial aims to evaluate the effect of recovery positions with bent or extended arm on perfusion of the lower forearm and comfort.

Methods: Eight healthy volunteers were placed in each of the recovery positions for 15 min, in random order, with an interval of 15 min in supine position. Various perfusion indices of the dependent arm were assessed by radial artery tonometry, ulnar artery echo doppler, and venous congestion plethysmography, as well as participant discomfort, pain and skin discoloration. Differences in outcomes were analyzed with linear mixed models.

Results: Our study found no statistically significant difference in systolic peripheral arterial pressure in the radial artery, peripheral venous pressure at the back of the hand, oxygen saturation, heart rate, subjective pain and discomfort, when comparing both postures. Participants slightly experienced more skin discoloration in the position with extended arm.

Conclusions: We conclude that, since perfusion of the dependent arm was shown to be similar in both positions, both recovery positions can be used. These conclusions fill a gap in evidence and can further support the treatment recommendations regarding the recovery position in first aid settings.

Keywords: Recovery position, Arterial flow, Blood pressure, Discomfort, First aid, Guidelines

Introduction

First aid and resuscitation guidelines recommend placing people experiencing decreased responsiveness due to medical illness or non-physical trauma, but who maintain normal breathing and do not necessitate rescue breathing or chest compressions (CPR), into a side-lying recovery position.[1,2] The recovery position serves to maintain an open airway and mitigate the risk of choking from vomit or fluids.[3,4] The evidence to support this recommendation is continuously being evaluated by the International Liaison Committee on Resuscitation (ILCOR) and is summarized in a "Consensus on First Aid Science with Treatment Recommendations".[5,6] This consensus is revisited every 5 years, informing the development of new resuscitation and first aid guidelines by various resuscitation councils and Red Cross Red Crescent National Societies worldwide. Overall, the evidence remains scarce, with very low certainty, making it challenging to recommend an optimal recovery position. Studies have identified seven distinct lateral recumbent recovery positions, varying from lateral to prone. However, the positions used were inadequately described to ensure reproducibility and clear recommendations.[5,6] For approximately two decades, the European Resuscitation Council (ERC) and other developers of first aid and resuscitation guidelines such as the Belgian Red Cross-Flanders (BRC-F), have recom-

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mended positioning the victim on their side with the dependent (lower) arm bent to support the other (upper) arm and with upper leg bent at right angles (Fig. 1A).[7,8]

During the first aid guideline update by the BRC-F in 2021, concerns arose regarding whether the upper arm would compress the brachial artery of the bent dependent (lower) arm, impairing perfusion and comfort, which was previously already suggested by anecdotical evidence from small studies.[4,9,10] Concurrently, during the development of the 2021 ERC guidelines, public commentary on this topic raised the issue that bending the arm could be problematic for victims with joint stiffness. Consequently, both ERC and the BRC-F now recommend that the dependent arm should be extended at right angles to the body, no longer using it to support the other arm (Fig. 1B).[1] However, a solid scientific base for this good practice recommendation is currently lacking.[5]

This study aims to investigate the effects of two different lateral side-lying recovery positions, with bent arm and with extended arm, on perfusion indices of the lower arm. The ultimate goal is to provide a solid scientific base for the recommendation about the recovery position.

Material and methods

This study was conducted at the Department of Cardiology, Antwerp University Hospital (Edegem, Belgium) between November 2022 and September 2023. This study was registered at Clinicaltrials.gov as NCT05587179 (September 15, 2022) and approved by the Ethics committee of Antwerp University Hospital in October 2022. We adhered to the Consolidated Standards of Reporting Trials (CONSORT) checklist.[11]

Study design and sample size

We conducted a randomized controlled trial (RCT) with a cross-over design, wherein all participants underwent both recovery positions, with the sequence randomized. Before and after each position, the participants were positioned supine. Each position was maintained for 15 min. Fig. 2 provides an overview of the study setup.

Sample size calculations were based on the hypothesis that different recovery positions would induce a difference in systolic peripheral arterial pressure. While a difference of 10% in the ankle-brachial index (i.e. 12 mmHg, assuming a normal systolic blood pressure (SBP) of 120 mmHg) is used to define clinically relevant peripheral artery disease,[12,13] we opted for a more conservative value of 6 mmHg as clinically significant. Drawing from scientific literature, we anticipated a standard deviation (SD) of 4 mmHg,[14] but analogously, we applied a more conservative value of 8 mmHg, in combination with a conservative correlation coefficient of 0.5 for the intraindividual correlation between measurements of SBP.

The minimum number of subjects needed to detect a true difference in population means with a mean difference (MD) of 6 mmHg, a SD of 8 mmHg, a power of 90%, and two-sided type I error probability of 5% was calculated with an online sample size calculator for a

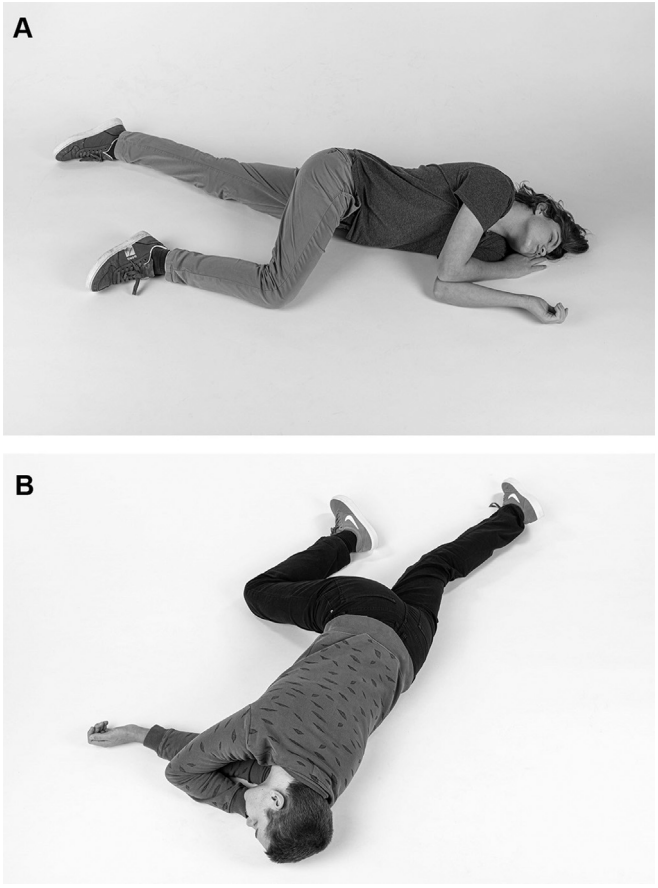

Fig. 1 – (A) Person placed in the lateral side-lying recovery position with bent dependent arm. (B) Person placed in the lateral side-lying recovery position with extended arm. © Frank Toussaint for Belgian Red Cross-Flanders.

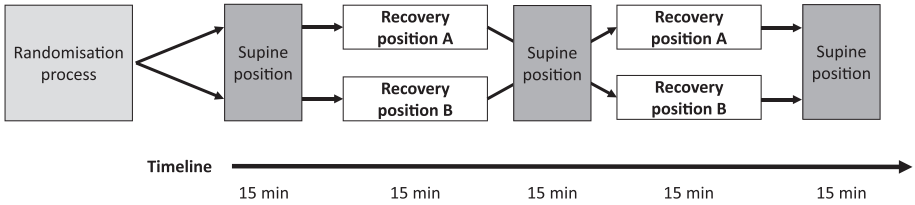

Fig. 2 – Overview of study set-up with cross-over design.

paired *t*-test,[15] and was estimated to be 24 (including 10% drop-out). Based on real-life data, showing a lower SD of the change scores in the first five study participants than anticipated (i.e. 15 mmHg), the sample size was reduced to six, even for a difference of 6 mmHg and a power of 90% (not taking into account dropout). For the other primary outcomes, the sample size varied from five to eight. Consequently, we proceeded with the experiment until eight measurements were successfully completed.

Study participants and randomization

Participants were healthy volunteers recruited from the Antwerp University Hospital between December 2022 and September 2023, all of whom provided written informed consent before any study procedures commenced. Eligible participants were healthy volunteers, aged $\geq$18 years and $\leq$65 years at randomization. Subjects with known risk factors for impaired blood flow were excluded based on criteria including a self-declared history of coronary or peripheral vascular disease such as Raynaud's disease or Thromboangitis Obliterans, type I or type II diabetes, self-reported intake of cholesterol-lowering medication, high blood pressure (defined as SBP $\geq$ 140 mmHg and/or diastolic blood pressure $\geq$ 90 mmHg), self-reported use of antihypertensive drugs, obesity (defined as BMI $\geq$ 30 kg/m^2), and self-reported smoking or tobacco use.

Prior to inclusion, potential participants completed a medical health questionnaire and underwent a physical examination at the Antwerp University Hospital.

This study is a cross-over RCT in which the sequence of the lateral recovery position was randomized. All participants who consented to participate and met the inclusion criteria were randomized. A researcher of the BRC-F, who was not involved in the execution of the study (HS), generated the randomization list of participants into sequences of recovery positions via the R package 'randomizeBE',[16] ensuring gender balance. Upon a participant's entry to the trial, the principal investigator of Antwerp University Hospital contacted the BRC-F for assignment to the sequence of recovery positions. The study participants were blinded to the current recommendation in terms of which recovery position was considered beneficial.

Recovery positions tested

One of the recovery positions tested, included the position with extended dependent arm aligned next to the upper lying arm supporting the head, as outlined in the current ERC guidelines.[1] To achieve this position the participant was rolled from supine position onto their side with the dependent arm extended at right angles to the body and the hand palm facing upward. The upper lying arm was brought across the chest, the back of the hand was placed against the participant's cheek, and the upper lying leg was adjusted so that both hip and knee were bent at right angles (Fig. 1B).

The other recovery position was the lateral side-lying recovery position with bent arms. This position resembled the one described above, with the exception that the dependent arm was positioned at right angles to the body, with the elbow bent and the palm facing upward (Fig. 1A).

All participants were positioned in the recovery positions by the same researcher of the Antwerp University Hospital, who had been trained by a BRC-F professional first aid trainer. To ensure the correct positioning, a voluntary first aid trainer of the BRC-F attended the first measurement, and photographs of the two postures of all subsequent participants were taken and reviewed by a member of the First Aid Service of the BRC-F.

Given that the response time for emergency care and transportation in most European countries is typically 15 min or less in life-threatening situations, participants remained in their respective recovery positions for 15 min as a deliberate choice.[17]

Outcomes of interest and data collection

Baseline characteristics of the study participants were collected on demographics and medication use. Clinical variables included height (cm), weight (kg), BMI, blood pressure, and heart rate. For blood pressure and heart rate, the average of three measurements was used. Primary outcomes included systolic peripheral arterial pressure in the dependent arm, derived from pulse wave amplitude measured by radial artery tonometry between 10 and 15 min in the supine or recovery position; cross-sectional area and peak systolic velocity of the ulnar artery of the dependent arm, measured by echo doppler between 10 and 15 min in the supine or recovery position; and peripheral venous pressure, assessed at the back of the hand of the dependent arm by venous congestion plethysmography between 10 and 15 min in the supine or recovery position. Secondary outcomes comprised oxygen saturation and heart rate, measured continuously during the study (the mean of measurements at 0, 10, 12.5 and 15 min was used as data point); discomfort and pain, measured on a 0–10-point Likert-scale (validated pain Numerical Rating Scale[18]) completed by the participants after 15 min in the recovery position; skin discoloration, measured on a 0–10-point Likert-scale (non-validated Numerical Rating Scale) completed by one researcher after 15 min in the recovery position. It was not possible to blind the outcome assessor for recovery position allocation.

Data collection and management was performed by an experienced researcher of the Antwerp University Hospital (DV), who entered and pseudonymized the original data in the secure, web-based software platform REDCap (Research Electronic Data Capture), hosted at Antwerp University.[19,20]

Data analysis

Researchers of the Belgian Red Cross, who were not involved in the conduct of the study and blinded to the allocation status, performed analyses on the pseudonymized data. Participant characteristics

were summarized using descriptive statistics, with means and standard deviations for continuous variables, median and inter-quartile ranges (IQR) for non-normal continuous data, and percentages for categorical data.

All outcome data (from all 8 participants) are presented as means with standard deviations and as summary effects using MDs with 95% confidence intervals (CIs). We applied mixed models, using the lme4 package in R,[21] to assess differences in outcomes between both recovery positions, taking into account the order of testing, the period, and a period-level baseline (i.e. the value of the outcome in the preceding supine position) as covariates.[22,23] The ordinal data on skin discoloration, pain, and discomfort were tested similarly, except for the absence of period-level baseline data, as these outcomes were not assessed in the preceding supine position. The Shapiro-Wilk test was used to test the residuals for normality. We accepted statistical significance at the 5% level, which was corrected for multiple outcome testing by the Bonferroni-Holm test. For convenience, we report adjusted p-values for each outcome, and not the adjusted alpha levels.

Results

Participant baseline characteristics

All eligible study participants (four men and four women) were between 25 and 39 years of age. Each participant had a normal BMI ranging from 21 to 25 kg/m^2. Three participants reported medication use: two women used hormonal anticonception, of whom one also used nutritional supplements (vitamin B and magnesium). One male participant used antiallergics. See Table 1 for an overview of all baseline characteristics.

Primary outcomes

Shapiro-Wilk tests of the residuals showed no deviations for normality. Regarding the systolic peripheral arterial pressure in the radial artery of the dependent arm, comparison between the recovery position with the extended arm and the one with the bent arm yielded a MD of −0.9 mm Hg, 95% CI [−2.2; 0.30] (p = 0.76), indicating no significant difference between the two positions. None of the intraindividual differences exceeded the threshold for clinical relevance (Fig. 3A).

At the ulnar artery of the dependent arm two outcomes were measured, i.e. peak systolic velocity and the cross-sectional area of the ulnar artery. The MD for peak systolic velocity comparing the extended versus bent arm was −0.8 cm/s, 95% CI [−7.0; 5.4] (p = 1) (Fig. 3B). For the cross-sectional area of the ulnar artery, the MD was 0.011 cm^2, 95% CI [0.000; 0.021] (p = 0.43) (Fig. 3C). However, as the 95% CI of the MD spanned both the value indicating no difference and the threshold for clinical relevance for both outcomes measured at the ulnar artery, the current sample size is inadequate for drawing high-certainty conclusions. Therefore we can only infer that there is no evidence of a difference between the two postures for these outcomes, rather than evidence for no difference.

The final primary outcome was the peripheral venous pressure at the back of the hand of the dependent arm, and also for this outcome, no difference was found between the two postures (MD for extended versus bent arm: 2.6, 95% CI [−0.9; 6.0] cm/s, p = 0.76) (Fig. 3D).

Table 1 – Baseline characteristics of the study population (N = 8). All data are means with SD, unless otherwise stated.

Variable (unit)	Mean (SD)
Age (year)	30.0 (5.0)
Sex (N and % males)	4 (50)
BMI (kg/m^2)	23.4 (1.2)
Systolic blood pressure (mmHg)	109 (12)
Diastolic blood pressure (mmHg)	67 (4)
Heart rate (bpm)	64 (10)
Medication use (N and %)	3 (37.5)

SD: standard deviation, BMI: body mass index; bpm: beats per minute.

Secondary outcomes

Also for the secondary outcomes Shapiro-Wilk tests of the residuals showed no deviations for normality. For both oxygen saturation (MD for extended versus bent arm: 0.49, 95% CI [−0.05; 1.03] %, p = 0.60) and heart rate (MD for extended versus bent arm: 2.7, 95% CI [0.0; 5.3] bpm, p = 0.60), no statistically significant difference was found between the two positions.

Regarding pain and discomfort no statistically significant difference was found between the two positions. The change in pain score for extended versus bent arm was 0.1 points, 95% CI [−0.7; 0.9] (p = 0.77), and for discomfort, the MD was 1.0 points, 95% CI [0.2; 1.8] (p = 0.40). However, there was a statistically significant increase in skin discoloration by 0.75 points in the position with extended arm compared to the position with bent arm (MD: 0.75, 95% CI [0.5; 1.0], p = 0.02), indicating that the participants exhibited slightly more skin discoloration in the extended arm position. See Supplementary Fig. 1 for the results of the secondary outcomes.

Discussion

Because of lack of high-certainty evidence about an optimal recovery position for unresponsive but normally breathing victims, we conducted a cross-over RCT to compare two different versions of the recovery position. One of the positions tested is a position that has been trained for many years, in which the victim has their dependent (lower) arm bent to support the upper arm. The other position is a slight variation thereof, with the dependent arm extended. This position has been recommended recently because of concerns about impaired venous drainage in the dependent arm and difficulty in bending the arm for individuals with joint stiffness.

Our study found no statistically significant difference in several indicators of perfusion in the dependent arm, such as systolic peripheral arterial pressure in the radial artery, and peripheral venous pressure at the back of the hand. However, due to the small sample size, we could not conclusively demonstrate differences in peak systolic velocity and cross-sectional area of the ulnar artery. Similarly, no significant differences were observed in heart rate and oxygen saturation between the two positions. While also pain and discomfort showed no significant differences, participants did experience more skin discoloration in the extended arm position, as evidenced by a statistically significant increase of 0.75 points on a 0–10-point scale.

Three previous studies did not compare these two positions, but focused on comparing a semi-prone position, halfway between a lateral and a prone position, with the lower arm behind the person, and

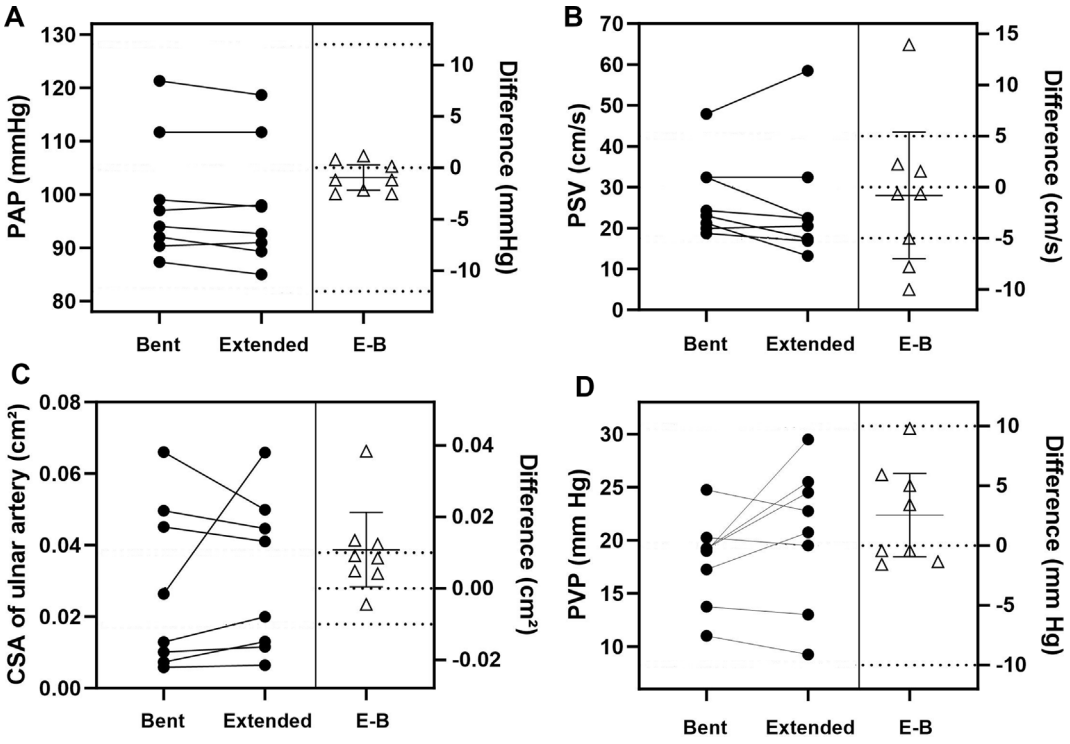

Fig. 3 – Results for primary outcomes. In the left part of each panel, black dots, connected with a black solid line, represent values measured for each participant. In the right part of each panel, open triangles represent the differences between the recovery position with extended dependent arm and bent dependent arm. The MD with 95% CI is also shown. Dotted lines represent no difference and the clinically relevant difference, in either direction. (A) Systolic peripheral arterial pressure (PAP); (B) Peak systolic velocity (PSV); (C) Cross-sectional area (CSA) of the ulnar artery; (D) Peripheral venous pressure (PVP).

the lateral recovery position with arms bent.[4,8,9] Two of these studies suggest that the semi-prone position shows less problems of arterial perfusion and venous drainage than the lateral position with arms bent.[4,9] However, in the third study it was shown that comfort and ease of placing a person in the recovery position was better in the position with arms bent,[8] which remained the preferred and recommended position in many guidelines between 2000 and 2020.

Our study's strength lies in its cross-over design, reducing between-participant variability, and requiring fewer participants to achieve obtain the same statistical power. To mitigate potential limitation of carry-over effects, a 15-minute washout period in the supine position was implemented. In our cross-over study the order of the positions was randomized, which was not the case in two of the three previous studies that compared different recovery positions.[4,8] In addition, our study has several other methodological strengths compared to existing research: a sample size calculation was conducted (to allow precise and accurate conclusions), data were normalized to the preceding supine position (which was also done by Rathgeber et al.[9]), and data were corrected for multiple outcome testing.

Our study shows some limitations at the level of study design. We did not use a standardized and validated scale to measure the outcome "skin discoloration", because such a scale is non-existent to our knowledge. This made it difficult to interpret the result of a 0.75 point increase on a 0–10 point scale in skin discoloration for the recovery position with extended arm, which was moreover contradictory to our hypothesis that rather the position with bent arms could lead to compromised venous drainage and, hence, skin discoloration. However, based on our content expertise, and because this result is not translated in significant differences in the objectively measured perfusion indices, we assume the current 0.75 point increase is not clinically meaningful, but we do recommend further exploring this outcome in future studies.

Inherent to this study topic, it was also difficult to blind the outcome assessors. This is not problematic for the objectively measures outcomes, all measured with standardized state-of-the-art techniques that are not prone to any influence of the researchers/assessors, and for the more subjective measures of pain and discomfort, since these are patient-reported outcomes and patients were unaware of the study hypothesis and blinded to the current recommendations concerning the recovery position. However, lack of blinding may imply a risk of bias for the outcome of skin discoloration, and in future studies it might be better to involve an independent outcome assessor, unaware of the study hypothesis.

Another limitation of our study is that the last three volunteers, who were only measured after the interim sample size calculation, introduced a higher standard deviation in peak systolic velocity and cross-sectional area of the ulnar artery than anticipated, which resulted in a large CI for the MD of these outcomes, complicating the interpretation of these data.

When it comes to generalizing our conclusions, we need to take into account that we only included healthy volunteers in this study. Therefore we cannot formulate general conclusions about discomfort, because the feeling of discomfort might be different for example for people with physical problems, pregnant women or people with

overweight. This was indeed shown for overweight casualties or people with back or neck problems.[8] Since perfusion of the dependent arm was shown to be the same in both positions, in fact both recovery positions can be used. Current recommendations, recommending the recovery position with extended arm, can stay in place but could mention that there is no difference with the position with bent arm, and that the choice for one of the postures might depend on which is more feasible to stably achieve for a specific person.

In conclusion, because of the lack of high-certainty evidence about the choice between recovery positions, and especially about the currently recommended recovery position with extended arm, our conclusions fill a current gap in evidence regarding the recovery position in first aid settings.

CRediT authorship contribution statement

Emmy De Buck: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Hans Scheers:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. **Philippe Vandekerckhove:** Writing – review & editing, Funding acquisition, Conceptualization. **Dorien Vermeulen:** Writing – review & editing, Methodology, Investigation, Data curation. **Hein Heidbuchel:** Writing – review & editing, Resources, Conceptualization. **Hilde Heuten:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100722.

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