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Monitoring colonoscopy withdrawal time significantly improves the adenoma detection rate and the performance of endoscopists

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Background and study aims: The recommended minimum withdrawal time for screening colonoscopy is 6 minutes. Adenoma detection rates (ADRs) increase with longer withdrawal times. We aimed to compare withdrawal times and ADRs of endoscopists unaware of being monitored vs. aware.

Patients and methods: Seven experienced gastroenterologists prospectively performed 558 screening colonoscopies during a 9-month period in a Swiss University hospital. Colonoscopy withdrawal times were first measured without the gastroenterologists' knowledge of being monitored (n=355 colonoscopies) and then with their knowledge (n=203 colonoscopies).

Results: The median withdrawal time when gastroenterologists were unaware of being monitored was 4.5 minutes (interquartile range [IQR] 4–5.5 minutes) without intervention and 6 minutes (IQR 4–9 minutes) with intervention, increasing significantly to 7.3 minutes (IQR 6.5–9

minutes) and 8 minutes (IQR 7–11 minutes), respectively, when they were aware of being monitored ($P<0.001$ both for colonoscopies with and without intervention). The ADR increased from 21.4% when the gastroenterologists were unaware of being monitored to 36.0% when they were aware ($P<0.001$). In the multivariate regression model, the endoscopists knowing they were being monitored was the strongest factor associated with ADR (odds ratio 4.417; 95% confidence interval [CI] 2.241–8.705; $P<0.001$).

Conclusions: Colonoscopy withdrawal time in unmonitored gastroenterologists is shorter than recommended and increases with awareness of monitoring. ADR significantly increases when gastroenterologists are aware of being monitored. Implementation of systematic monitoring, and analysis of withdrawal time and ADR for each endoscopist may help to increase the ADR.

Introduction

Screening for colorectal cancer (CRC) is currently being or has been introduced in many countries in Europe [1]. In the last decade, colonoscopy has emerged as the most effective CRC screening strategy [2–5] preventing approximately 80% of CRCs [6,7]. However, colonoscopy has inherent limitations and its performance with a high level of quality is of crucial importance.

The European Society of Gastrointestinal Endoscopy (ESGE) recommends that national boards should monitor quality indicators and use them to license individual colonoscopists and endoscopy units [8]. Such quality indicators include, among others, bowel cleansing, cecal intubation rate, detection rate of adenomas and cancers, withdrawal time, retrieval rate of polyps, and re-

cording of early and late adverse outcomes, such as perforations and bleeding [8]. Withdrawal time is defined as the length of time the colonoscopist spends withdrawing the colonoscope from the cecal pole to the anus. It is during this phase of the examination that detailed mucosal inspection for adenomas takes place. Withdrawal time has been particularly associated with polyp detection [9–13].

Two large studies have supported a minimum withdrawal time of 6 minutes in diagnostic colonoscopies without interventions such as polyp retrieval [9,11]. Barclay et al. [9] showed a threefold difference (9.4% to 32.7%) in adenoma detection rate (ADR) depending on the duration of withdrawal (which ranged from 3.1 to 16.8 minutes). Colonoscopists with withdrawal times longer than 6 minutes had higher detection of any neoplasia (28.3% vs. 11.8%). Another and more recent analysis of the British CRC screening program

* The first two authors contributed equally to this article.

showed that withdrawal times of 10 minutes were associated with the best ADR [14]. Therefore, the ESGE recommends a colonoscopy withdrawal time of at least 6 minutes, and gastroenterologists should increase their efforts to fulfil this goal. One method of achieving this goal is to actively monitor the withdrawal time; however, it is unknown whether this really increases the withdrawal time and also the ADR.

The aim of our study was to monitor the withdrawal time in two distinctly different preconditions: with or without endoscopists' knowledge that their withdrawal times were being monitored. We hypothesized that the mean withdrawal time of gastroenterologists who were unaware of being monitored would be shorter than recommended and that the same gastroenterologists, when they were aware of being monitored, would increase their withdrawal time. We further hypothesized that a longer withdrawal time would lead to an increase in the ADR. Finally, we aimed to investigate the gastroenterologists' accuracy in estimating their own withdrawal time.

Patients and methods



Patients

During a 9-month period, outpatients referred for CRC screening colonoscopy to the Division of Gastroenterology and Hepatology of the University Hospital of Basel, Switzerland, a tertiary referral center, were prospectively included in this trial. The following inclusion criteria were applied: age > 18 years, referral for screening colonoscopy, and written informed consent provided. Patients were excluded if they fulfilled one or several of the following criteria: hospital inpatients, insufficient bowel preparation (according to Froehlich et al. [15]), previous colorectal surgery, or missing informed consent for colonoscopy.

Seven experienced gastroenterologists (each having undertaken >500 colonoscopies) performed the screening colonoscopies using Olympus EVIS EXERA II 180 series with high definition technology (Olympus, Tokyo, Japan). The type of endoscope (e.g. standard colonoscope, pediatric colonoscope) was chosen by the endoscopist. White-light endoscopy was used, and contrast dye was not routinely applied during colonoscopy. Withdrawal was performed by the endoscopist.

Bowel preparation was achieved using polyethylene glycol (Macrogol; Norgine, Amsterdam, The Netherlands), with 3 L administered on the night prior to the procedure, followed by another liter in the morning of the procedure. The procedures were performed on the patients under conscious sedation using non-anesthesiologist-administered propofol (AstraZeneca AG, Zug, Switzerland). Patients with multiple morbidities and/or American Society of Anesthesiologists (ASA) classification III/IV were evaluated by anesthesiologists who decided whether to perform the procedure with monitored anesthesia care or general anesthesia.

Methods



In the first phase of this study, withdrawal time was monitored by an endoscopy nurse who was aware of the study, without the endoscopists knowing that they were being monitored. The endoscopists were not informed about the study until the first part was completed. Withdrawal time was measured as exact time in minutes and seconds. The endoscopy nurses were trained

to deal with measuring the withdrawal time using a stopwatch without attracting the endoscopist's attention. During this part of the study, the measured withdrawal time was not documented on the usual report form, but was instead recorded on a separate sheet that was not given to the endoscopist.

During the second phase of the study, the same endoscopists were informed that the withdrawal time was going to be monitored. In addition, the endoscopist was required to estimate his own withdrawal time after each colonoscopy.

The time periods of both study phases were predefined (each 4.5 months), and once the time period for the first phase of the study was over, the second phase of the study began.

The patient characteristics, the quality of bowel cleansing, and the ADR were recorded. Cleansing quality was characterized according to the study of Froehlich et al., where colon cleansing was assessed by the endoscopist, on a 5-point scale: high cleansing quality, completely clean (score 5); clear liquid present (score 4); liquid plus solid stool present that can be aspirated (score 3); liquid and solid stool present that cannot be totally aspirated (score 2); or solid stool preventing visualization (score 1) [15].

A standardized procedure of polyp retrieval was used: polyps up to a size of 5 mm were removed by biopsy forceps and, for those > 5 mm, an electrical snare was used after submucosal injection with 1:10 000 diluted adrenaline in saline. Data regarding the specific histologic type of adenoma (e.g. sessile serrated adenoma, tubulovillous adenoma, tubular adenoma) were not collected, except for a diagnosis of cancer.

This study was part of a quality audit program at the hospital. It was approved by the local Ethics committee.

Statistical analysis

The data were entered into a database (Microsoft Access 2000). All statistical analyses were performed with a statistical program (STATA, Version 12, College Station, Texas, USA). Data distribution was analyzed using the Shapiro-Wilk test for normal distribution. Results of quantitative data are presented as either mean \pm standard deviation (SD) and range for parametric data (referring to data with Gaussian distribution) or median plus interquartile range (IQR) for non-parametric data. Categorical data were summarized as the percentage of the total group.

Differences in quantitative data distributions were assessed by the Student's *t* test (for parametric data), and the Mann-Whitney and Wilcoxon rank sum tests (for non-parametric data). A *P* value of <0.05 was considered statistically significant. A Bonferroni correction was performed where multiple testing was undertaken.

We performed binary logistic regression with "adenoma detection" as a binary dependent variable and multinomial logistic regression with "withdrawal time" (once without, and once with intervention) as continuous dependent variables. The analyses were performed with STATA v12. First the independent variables (monitoring Yes/No, number of endoscopists, sex (male vs. female), age of patients (continuous outcome in years), and bowel preparation (categorical outcome) were entered one by one into the logistic regression. Variables with a *P* value <0.1 were then entered into the multivariate logistic regression model.

Results

Baseline characteristics

A total of 590 patients were screened of whom 27 were excluded because of poor bowel preparation, three because of previous colorectal surgery, and two because their records of informed consent were missing. Therefore, 558 patients were included in phases one and two. During the first phase of the study in which gastroenterologists were unaware of the withdrawal time being monitored, 355 patients underwent a screening colonoscopy. In the second phase of the study, when the gastroenterologists knew they were being monitored, 203 patients were recruited. The patient characteristics of all 558 patients are shown in **Table 1**.

The quality of colon cleansing was as follows: poor, $n=0$ patients (0%); substandard, $n=24$ (4.3%); adequate, $n=48$ (8.6%); good, $n=470$ (84.2%); and very good, $n=16$ (2.9%). Cleansing did not significantly differ in the two parts of the study.

The number of endoscopies performed per endoscopist were as follows: endoscopist #1, 129 colonoscopies (23.1%); endoscopist #2, 102 colonoscopies (18.2%); endoscopist #3, 79 colonoscopies (14.2%); endoscopist #4, 72 colonoscopies (12.9%); endoscopist #5, 68 colonoscopies (12.2%); endoscopist #6, 63 colonoscopies (11.3%); endoscopist #7, 45 colonoscopies (8.1%). A total of six CRCs were detected in the 558 patients (1.1%). Mean polyp size was 7 ± 6 mm (range 2–35 mm).

Withdrawal times when endoscopists were unaware of being monitored

A total of 355 patients were included for the first phase of the study. We detected significant variations in the withdrawal time among different gastroenterologists ($P < 0.001$), both for colonoscopies without and with intervention. The median colonoscopy withdrawal times without intervention and with intervention in the first part of the study were 4.5 minutes (IQR 4–5.5 minutes) and 6 minutes (IQR 4–9 minutes), respectively ($P < 0.001$) (**Fig. 1**). The proportion of colonoscopies without interventions that had a withdrawal time < 6 minutes was 85.3% (**Fig. 1**).

Table 1 Characteristics of the patients undergoing screening colonoscopy in the two phases of the study.

	Phase 1	Phase 2	P value
Number of patients	355	203	NA
Sex, male, n (%)	196 (55.2)	93 (45.8)	0.037
Median age at colonoscopy, years	59.9	60.1	0.998
Cecal intubation rate, %	100%	100%	1.0

NA, not applicable.

Withdrawal times when endoscopists were aware of being monitored

In the second phase of the study, gastroenterologists were informed that the withdrawal time was being monitored by the endoscopy nurse during the colonoscopy. A total of 203 patients (93 men [45.8%]) were recruited and underwent colonoscopy during this phase.

The median colonoscopy withdrawal time without intervention was 7.3 minutes (IQR 6.5–9 minutes) compared with 8 minutes (IQR 7–11 minutes) for those including polypectomies ($P < 0.001$). The endoscopists' estimated median colonoscopy withdrawal times without and with intervention were 7 minutes (IQR 6–8 minutes) and 8 minutes (IQR 7–10 minutes), respectively ($P < 0.001$).

Compared with the first phase of the study, we observed that the median objectively measured colonoscopy withdrawal time significantly increased in colonoscopies both without and with interventions when endoscopists were made aware of withdrawal time monitoring (increase of 2.8 minutes and 2 minutes in the groups without and with intervention, respectively; $P < 0.001$). The proportion of colonoscopies without interventions that had a withdrawal time < 6 minutes decreased to 13%.

Comparing the objectively measured withdrawal times with those that were subjectively estimated for colonoscopies without intervention, we found that the objective median withdrawal time was not significantly different from the subjectively estimated median withdrawal time (7.3 minutes [6.5–9 minutes] vs. 7

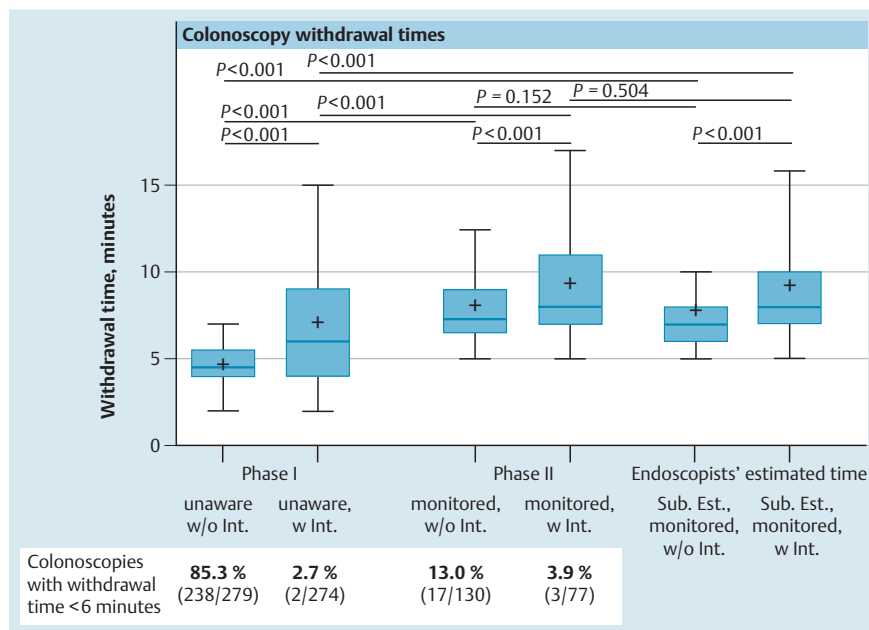


Fig. 1 Colonoscopy withdrawal time according to awareness of monitoring and intervention. Boxplots showing interquartile range (outer limit of the box), mean value (black cross), and 95% confidence interval (whiskers) of withdrawal times for colonoscopies with intervention (w. Int.) or without intervention (w/o Int.) that were measured when the endoscopists were unaware of being monitored (Phase I), when they were aware of being monitored (Phase II), and that show the endoscopists' subjective estimations during phase II.

Continuous outcome "withdrawal time without intervention"				
	Univariate model		Multivariate model	
	Odds ratio (95%CL)	P value	Odds ratio (95%CL)	P value
Adenoma detection	1.822 (1.337, 2.306)	<0.001	0.604 (0.004, 1.212)	0.051
Number of polyps	0.641 (0.449, 0.834)	<0.001	0.335 (0.098, 0.572)	0.006
Endoscopists	-0.249 (-0.354, 0.144)	<0.001	-0.012 (-0.097, 0.073)	0.785
Patient sex, male	-0.149 (-0.597, 0.299)	0.513	-	
Patient age, years	0.007 (-0.008, 0.214)	0.363	-	
Bowel preparation	0.242 (-0.193, 0.676)	0.276	-	
Awareness of monitoring	3.421 (3.051, 3.791)	<0.001	3.250 (2.876, 3.624)	<0.001

95%CL, 95% confidence limits.

Table 2 Linear regression model for withdrawal time for colonoscopies *without* intervention.

Continuous outcome "withdrawal time with intervention"				
	Univariate model		Multivariate model	
	Odds ratio (95%CL)	P value	Odds ratio (95%CL)	P value
Adenoma detection	4.768 (4.113, 5.423)	<0.001	2.161 (1.182, 3.139)	<0.001
Number of polyps	1.907 (1.651, 2.163)	<0.001	1.196 (0.816, 1.577)	<0.001
Endoscopists	-0.220 (-0.381, 0.059)	0.007	-0.001 (-0.138, 0.135)	0.984
Patient sex, male	0.296 (-0.381, 0.974)	0.391	-	
Patient age, years	0.021 (-0.001, 0.043)	0.065	-0.002 (0.020, 0.159)	0.810
Bowel preparation	0.283 (-0.373, 0.939)	0.398	-	
Awareness of monitoring	2.249 (1.569, 2.928)	<0.001	1.687 (1.087, 2.287)	<0.001

95%CL, 95% confidence limits.

Table 3 Linear regression model for withdrawal time for colonoscopies *with* intervention.

minutes [6–8 minutes]; $P=0.152$). Similarly, the objective median withdrawal time for colonoscopies including interventions was not statistically different from the subjectively estimated median withdrawal time (8 minutes [7–11 minutes] vs. 8 minutes [7–10 minutes]; $P=0.504$). These different time intervals are illustrated in [Fig. 1](#).

Linear regression model for withdrawal time

The linear regression model for withdrawal time showed that for "withdrawal time *without* intervention" the fact that the endoscopist was aware of being monitored strongly positively influenced the withdrawal time (odds ratio [OR] 3.250, 95% confidence interval [CI] 2.876–3.624; $P<0.001$; [Table 2](#)). We found that for the length of the "withdrawal time *with* intervention" the following factors were positively associated in the multivariate analysis: adenoma detection, number of polyps, and the fact that the endoscopist was aware of being monitored ([Table 3](#)).

Adenoma detection rate increases with longer colonoscopy withdrawal time

In the first phase of this study, adenomas were detected in 76 out of 355 patients, giving a calculated ADR of 21.4%. In the second phase of the study, adenomas were found in 73 out of 203 patients, giving a calculated ADR of 36.0%. This increase was statistically significant ($P<0.001$; [Fig. 2](#)).

Univariate and multivariate logistic regression model for the outcome "adenoma detection"

In the multivariate model, the endoscopist being aware of monitoring was the strongest factor associated with adenoma detection (OR 4.417; $P<0.001$). Male sex was not significantly associated with adenoma detection. Details are shown in [Table 4](#).

Binary outcome “adenoma detection” (yes vs. no)				
	Univariate model		Multivariate model	
	Odds ratio (95%CI)	P value	Odds ratio (95%CI)	P value
Awareness of monitoring				
Yes	2.061 (1.406 – 3.022)	<0.001	4.417 (2.241 – 8.705)	<0.001
No	Reference			
Endoscopists				
	0.885 (0.809 – 0.969)	0.008	0.925 (0.819 – 1.042)	0.201
Patient sex				
Male	1.461 (0.999 – 2.138)	0.051	1.402 (0.871 – 2.258)	0.164
Female	Reference			
Patient age, years				
	1.026 (1.012 – 1.039)	<0.001	1.024 (1.008 – 1.041)	0.003
Bowel preparation				
	0.779 (0.551 – 1.102)	0.159	–	
Withdrawal time for colonoscopies without intervention				
	1.291 (1.193 – 1.397)	<0.001	0.614 (0.514 – 0.733)	<0.001
Withdrawal time for colonoscopies with intervention				
	1.431 (1.333 – 1.436)	<0.001	1.799 (1.583 – 2.045)	<0.001

95%CI, 95% confidence interval.

Table 4 Univariate and multivariate logistic regression model for the outcome “adenoma detection.”

Discussion

The performance of colonoscopies with a high level of quality is regarded as an effective strategy to reduce CRC-associated morbidity and mortality. Indicators of quality in colonoscopy include various items, such as cecal intubation rate, adequate colon cleansing, and a minimum withdrawal time from the cecum backwards of 6 minutes [16]. The withdrawal time is fully operator dependent.

Our study adds novel and clinically relevant insights to this topic of the quality aspects of colonoscopy. Whereas previous studies of withdrawal techniques and ADR have always focused on physicians who were aware of being monitored [9, 11, 12], in this study we show for the first time our results with regard to withdrawal time in endoscopists who were unaware that they were being monitored. Obviously, the endoscopists' practice regarding withdrawal time is strongly influenced by his/her knowledge of being monitored. With 85.3% of colonoscopies without intervention having a withdrawal time <6 minutes, we found that the endoscopists' adherence to the recommended withdrawal time of at least 6 minutes was very low in a “real-world setting,” meaning when they were unaware that their withdrawal time was being monitored.

Low adherence to the recommended withdrawal time seems to be of concern. Butterly et al. [17] demonstrated that nearly a quarter of endoscopists had median withdrawal times (without interventions) of 6 minutes or less. Our data further support the findings of Barclay et al. [18] who showed that using a timer to assist colonoscopists can lengthen the withdrawal time and improve ADR. Sawhney et al. [19] reported that recording of the exact withdrawal time at the end of the procedure by the endoscopy nurse and reporting compliance rates to colonoscopists can improve compliance with a 7-minute withdrawal time from 65% to almost 100%. Similarly, Sinn et al. [20] found that formal documentation of withdrawal time forced endoscopists to lengthen their withdrawal time. We conclude that endoscopists' know-

ledge that a quality measure is being monitored represents a powerful tool that can in itself increase the quality of colonoscopy.

We found that ADR significantly increased with the endoscopists' knowledge of being monitored with regard to withdrawal time. The positive association between withdrawal time and ADR has been shown by other studies [14, 17]. Both of these studies showed a statistically significant correlation between longer withdrawal time and higher ADR, peaking at 9 minutes. Butterly et al. [17] demonstrated the benefit of longer withdrawal time for serrated polyps too, defined as sessile serrated adenoma and hyperplastic polyps proximal to the sigmoid colon. When modeling was used in that study, it was determined that setting the minimum withdrawal time at 9 minutes would result in adenoma and serrated polyps being detected in 3.8% and 2.4% more patients (relative increase of 30%). More importantly, the increase in ADR has been shown to directly translate into a decrease in inter-

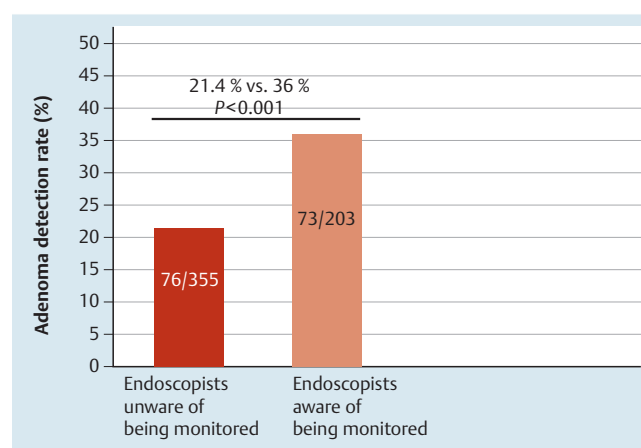


Fig. 2 Adenoma detection rate (ADR) in the two phases of the study. The increase in ADR was statistically significant ($P < 0.001$).

val CRCs [21,22]. Therefore, such a simple and easily implementable intervention as standardized monitoring of withdrawal time within gastroenterology units may ultimately prevent numerous cancer deaths.

Our study has several strengths and some limitations as well. The major strength is that this study represents the first time a clear and unbiased change in endoscopists' habits before and after being made aware that their withdrawal times were being monitored. When they knew that the withdrawal time was being measured and documented, the endoscopists obviously placed more attention on the quality of the colonoscopy and performed a more meticulous examination. This phenomenon is also known as the Hawthorne effect. During observational studies in the 1920s in the Hawthorne Western Electric Company, Chicago, USA, it was found that workers increased their productivity when they knew that they were observed in a study. As a consequence of this effect, ADR significantly increased; however, we were unable to show whether this was an ongoing effect over a longer period of time. An additional strength was that the prospective assessment reduced potential bias.

Some limitations should be discussed as well. First, withdrawal technique may be more important than withdrawal time [19, 23–26]. We did not assess withdrawal techniques in our study. Among the elements comprising a decent withdrawal technique, vigilant observation, fold examination, and good colonic distension are to be mentioned; however, these parameters are much more difficult to monitor and quantify. Therefore, the duration of withdrawal may be a surrogate for an adequate withdrawal technique and indeed duration has served as such a proxy in the majority of trials investigating correlations between the modality of withdrawal and ADR. Presumably, maneuvers to improve mucosal inspection (which incidentally increases withdrawal time), such as repositioning the patient, adequate insufflation and suction, meticulous mucosal re-inspection, careful inspection of the proximal aspect of folds, and rectal retroversion, are performed more frequently by “good” colonoscopists, which ultimately leads to higher ADRs and longer withdrawal times. Further limitations are the absence of a long-term study period and a relatively low statistical power to assess differences between endoscopists.

Our study highlights the importance of measuring and documenting withdrawal time in everyday practice. The knowledge that colonoscopy withdrawal time is being measured results in endoscopists significantly increasing their withdrawal time and consequently detecting more polyps. When they are aware of being monitored, endoscopists were accurate in estimating the measured withdrawal time. Our data indicate that simply monitoring and documenting withdrawal time can improve the quality of colonoscopy in daily practice and ultimately prevent interval cancer and cancer death.

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Competing interests: None

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