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Economic burden of knee joint replacement in Iran

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Abstract

Background The knee is the most commonly afflicted weight-bearing joint. Osteoarthritis of the knee is regarded as one of the most commonly diagnosed causes of disability in the elderly. Knee joint replacement can be regarded as a final solution for Osteoarthritis of the knee in which the joint is worn out, accompanied by clinical symptoms such as pain, deformity, and limited movement.

Aim this study sought to estimate the economic burden of knee joint replacement procedures carried out in Iran.

Method This cross-sectional descriptive study utilized the Incidence-based approach to assess the economic burden of knee joint replacement surgeries conducted in Iran during 2022, estimating the costs of the disease from a societal perspective. The sampling method employed was random sampling, and the sample size consisted of 300 patients. Direct costs were calculated employing the top-down approach, while indirect costs were estimated using the human capital approach. Microsoft Excel was employed for data analysis.

Result The average direct medical costs of the knee replacement procedure per patient were $10,076.87 and $13,099.93 in the public and private sectors, respectively. The average direct non-medical costs of knee joint replacement surgery are $1123.64, with companion costs constituting most of the direct non-medical costs. Finally, the economic burden of the knee joint replacement surgery was estimated at $67340417.28.

Conclusion Despite insurance coverage, knee joint replacement surgery in Iran incurs substantial costs. With the anticipated rise in the elderly population, the frequency of these procedures is expected to increase, amplifying the economic burden on the Iranian public.

Keywords Direct cost, Indirect cost, Knee joint replacement, Iran

Background

Osteoarthritis of the knee is regarded as one of the most commonly diagnosed causes of disability in the elderly [1–3]. Patients afflicted with osteoarthritis of the knee suffer from progressive disability in walking, ascending, and descending stairs. On the other hand, about one-third of the elderly develop osteoarthritis, whose rate rises with an increase in age [4, 5] and the obesity rate [6].

The knee is the most commonly afflicted weight-bearing joint when osteoarthritis occurs, whose interior side is ten times more likely to suffer than its exterior side. Considering the fact that arthritis disproportionately

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afflicts the aging population, the number of arthritis-afflicted people will inevitably increase with an increase in the number of elderly people [7].

Correlated with a wide range of factors, including genetic tendency, environmental factors, changes in lifestyle, and aging, osteoarthritis is recognized as one of the most prevalent causes of chronic pain and dysfunction among the elderly [8]. On the other hand, the rate of symptomatic osteoarthritis of the knee has augmented worldwide due to the rising number of young people suffering from obesity and an increased life expectancy [9–11], with osteoarthritis of the joints being the main cause of the problems that people over 67 years old are suffering [12].

Accordingly, 23% of the world population aged over-53 years old is estimated to have developed osteoarthritis. In this regard, while 6 million people develop osteoarthritis in France annually, the rate ranges between 1.3 and 1.75 million people in Britain. According to a study conducted in Beijing on the prevalence of osteoarthritis among over 60-year-old Chinese people, the rate was found to be 15.0% and 5.6% for women and men, respectively [13].

In Iran, the prevalence of total knee arthroplasty in the age group over 48 is higher than in other age groups and 81.3% of the patients who had undergone total knee arthroplasty were women. The demand for total knee arthroplasty in the Iran provinces varied a lot, so that the provinces of Tehran, Azerbaijan-Sharghi and Isfahan had the highest demand for total knee arthroplasty, and Bushehr and Kohkiluyeh and Boyer-Ahmad provinces had the lowest demand. most of the total knee arthroplasty was performed in the northern part of the country, so that Tehran province with 3075 cases, East Azerbaijan and Isfahan each with 1702 cases had the most total knee arthroplasty [14].

Osteoarthritis can be treated by various methods, including medication, changing the lifestyle, losing weight, using crutches, strengthening the muscles, using heels, and applying surgical methods such as arthroscopic debridement and osteotomies [15].

Merely slowing the progress of the disease, all of the aforementioned methods exert only a palliative effect. However, knee joint replacement can be regarded as a final solution for those knee diseases in which the joint is worn out, accompanied by clinical symptoms such as pain, deformity, and limited movement [16].

Known as one of the most successful orthopedic surgeries, modern knee arthroplasty started in the early 1970s with the evolution of knee prostheses, whose lasting chances are 37% in patients aged 53 to 56 years old. The main indication for replacing the knee joint is to relieve the knee's severe pain which may or may not be accompanied by pain.

Compared to other treatments recommended for osteoarthritis of the knee, the replacement of the knee joint has proved to be significantly the best, considering its costs and the fact that the patient's quality of life is increased and their pain is relieved over the years after the procedure is carried out. In other words, the knee joint replacement procedure is an effective treatment method to relieve the patient's pain, restore their function, and improve their quality of life [17–20].

However, while there is no unanimous agreement over the best knee arthroplasty method, such a procedure is commonly administered worldwide. For instance, over 30,000 knee joint replacement procedures are annually carried out in England. Being a complicated surgical operation, knee joint replacement requires detailed multi-faceted examinations before and after the procedure to achieve the best results [21].

In 2009, knee arthroplasty was the 14th leading cause of hospitalization in the United States, accounting for 22% of hospital admissions per 10,000 population [22]. According to the hospital records obtained from 28 American states, some 515,400 knee joint replacement procedures were carried out in 2007 at a hospital cost of nearly $16 billion. In this regard, the number of knee joint replacement surgeries in the United States is predicted to involve approximately 3.3 million people annually by 2030 [23].

Throughout the past thirty years, various cost-disease studies have been conducted, many of which have positively contributed to the negotiations made over public health policies and treatment, highlighting the extent of the influence of a disease on a society or a part of society. On the other hand, considering the extremely high costs of knee joint replacement treatment services, the costs imposed on society by such a disease are estimated to be rising both domestically and internationally.

Losina et al. in their study evaluated the cost-effectiveness of knee joint replacement surgery in the Medicare population, analyzing the costs associated with the procedure and its clinical outcomes. They developed a Markov, state-transition, computer simulation model and populated it with Medicare claims data and cost and outcomes data from national and multinational sources. Overall, TKA increased QALE from 6.822 to 7.957 quality-adjusted life years (QALYs). Lifetime costs rose from $37 100 (no TKA) to $57 900 after TKA, resulting in an incremental cost-effectiveness ratio of $18 300 per QALY. For high-risk patients, TKA increased QALE from 5.713 to 6.594 QALY, yielding a cost-effectiveness ratio of $28 100 per QALY. At all risk levels, TKA was more costly and less effective in low-volume centers than in high-volume centers [24].

Gandhi in systematic review study assessed the economic impact of knee joint replacement surgeries,

examining direct and indirect costs, effects on employment, quality of life, and the role of health insurance in covering associated expenses. Thirty-two studies were included in this review, out of which eight studies used Markov model, five used regression model, one each reported Marginal structure model, discrete simulation model, decision tree and Osteoarthritis Policy Model (OAPol) respectively to assess the cost-effectiveness of TKR. For PPP, twenty-six studies were included in the analysis of TKR cost. The average cost of TKR surgery was the lowest in developing country-India ($3457) and highest in USA ($19568) [25].

These studies represent a subset of the research conducted on the economic burden of knee joint replacement surgeries, highlighting various aspects of costs, outcomes, and implications for healthcare systems and patients.

The demand for knee joint replacement surgeries, also known as total knee arthroplasty (TKA), has been steadily rising in recent years. This trend can be attributed to several factors, including an aging population, increasing rates of obesity, and the prevalence of conditions such as osteoarthritis and rheumatoid arthritis. According to a study by Kurtz et al. (2007), the demand for TKA is projected to continue increasing substantially, with estimates suggesting that by the year 2030, the number of TKAs performed annually in the United States alone could reach 3.48 million [26].

Economic burden studies focusing on knee joint replacement surgeries are vital for understanding the broader impact of this intervention on healthcare systems and society as a whole. These studies assess the direct and indirect costs incurred by patients, healthcare providers, and society at large. They provide valuable insights into the financial implications of knee joint replacement surgeries, including hospitalization costs, rehabilitation expenses, and productivity losses due to disability [27].

By quantifying the economic burden of knee joint replacement surgeries, policymakers and healthcare stakeholders can make informed decisions regarding resource allocation, reimbursement policies, and healthcare delivery models. Moreover, economic burden studies help identify opportunities for cost-saving measures and the development of more efficient and sustainable healthcare strategies. In light of the growing prevalence of knee osteoarthritis and the increasing demand for knee joint replacement surgeries, it is essential to prioritize research efforts aimed at assessing and mitigating the economic burden associated with these procedures. By addressing the economic challenges posed by knee joint replacement surgeries, we can ensure equitable access to care, optimize healthcare delivery, and improve patient outcomes [28].

Taking into account the aforementioned points, the significance of orthopedic diseases, the costs imposed by such diseases on society, and the necessity of improving the efficiency of allocating the limited resources of the health system in terms of the economics of orthopedic diseases, this study sought to estimate the economic burden of knee joint replacement procedures carried out in Iran.

Method

This cross-sectional descriptive study used the Incidence-based approach to calculate the economic burden of knee joint replacement surgeries performed in Iran, estimating the costs of the disease from the social perspective. The sampling method employed was random sampling, and the sample size consisted of 300 patients. The samples were selected using the simple random sampling method based on the random numbers table and were entered into the study. This method helps ensure representativeness and reduces the risk of bias, particularly when studying the economic burden across different demographic groups or geographic regions.

To this end, direct and indirect costs were calculated based on the top-down and human capital approaches, respectively.

Direct costs include hospitalization, companionship, home care, travel, intracity and intercity commuting, and the time required for visiting a doctor and purchasing medications. Indirect costs include the extent of lost production, failing to be present at work or sick leave, and lost productivity during hospitalization.

To calculate the average costs of the private sector, the average costs calculated in the public sector were multiplied by the tariff coefficient of the private sector. Then, according to the distribution of patients in the private and public sectors, the average costs calculated in the public and private sectors were multiplied by the number of patients in the private and public sectors.

Participants of the study

The population of the study comprised of all those patients who underwent knee joint replacement procedures in Iran in 2022, from among whom 300 patients together with their medical cases were selected as the study's sample to estimate the total costs of the disease. The sample consisted of patients who were referred to Shafa Hospital for replacing their knee joints. Shafa Hospital in Tehran is known as the knee joint replacement center in Iran.

According to the criteria set for the selection of the participants, only the patients over 50 years old who had undergone the knee joint replacement procedure and were admitted to the Shafa Hospital were selected to take part in the study.

Data collection

The costs intended to be examined in this study were classified into three categories: Direct medical costs, direct non-medical costs, and indirect costs (incurred by the lost productions).

Direct costs (Medical and non-medical)

The direct medical costs investigated in the current study included the doctor's visit fee and medical consultations, medications and the materials used in the general ward, radiology, laboratory, CT scan, ultrasonography, electrocardiography, MRI, nursing services, and hospital hoteling. In this regard, first, the average direct costs per patient were estimated using a survey study. Moreover, direct medical costs were extracted from the hospital records of the patients.

On the other hand, direct non-medical expenses comprised of companionship, home care, commuting, and the time dedicated by the patient's companion to take care of him/her, the information of which was collected through a questionnaire. Moreover, complementary data in this regard was taken from the patients themselves or their companions by contacting them on phone.

The administered questionnaire was constituted of two sections: The first section collected the demographic information of the patients, including age, sex, marital status, education level, occupation, place of residence and insurance coverage status The second section was concerned with direct costs, including home care, the time required for visiting a doctor and purchasing medications (in hours), intra-city and inter-city transportation, accommodation, and companionship.

The questionnaire was developed by the researchers of this study based on previous studies, whose validity was confirmed through interviews with experts in epidemiology, health economics, and medical specialists [29]. The initial questionnaire made by a researcher included 30 questions. At this stage, according to the opinion of the research team and experts in the field of health economics, 12 questions were reviewed. In the validation phase, the experts believed that all the questions have sufficient necessity in the study. The questionnaire was administered through a pilot study and revised based on the obtained results.

Indirect costs

The third section was related to indirect costs, including the daily wage rate, the days the patient is absent from his workplace or the sick leave days, the patient's companion, and the length of hospitalization (in days). Indirect cost are loss-of-production-related costs that are imposed on society due to a patient's disability. As the current study did not observe any case where the replacement of the knee joint had led to death, the lost years of the patients' life due to premature death have not been included in calculating the economic burden of such a procedure.

Analysis

To calculate the average direct medical costs per patient, the number of services used by each patient was multiplied by the services' fee in 2022.

Estimating the indirect costs requires the calculation of the potential productions lost due to death and the potential productions lost due to disability. However, here the former is not necessary to be calculated, as there is usually no risk of death in knee joint replacement surgery. Therefore, the disability-based loss in potential productions was calculated by multiplying the average days of hospitalization by the number of patients by the average daily wage.

To this end, first, the number of days each patient was absent from his/her workplace due to disability was identified through interviews with experts and a review of information published in previous studies. Moreover, the total number of days in 2022 that the patients were unable to work was worked out using the estimated incidence and prevalence rates. Then, to calculate the costs of disability due to the knee joint replacement procedure, the number of disability days was multiplied by the average daily wages in 2022.

Furthermore, the employment rate was extracted from the data collected from Iran's Statistical Center and previous studies. While unemployed patients do not receive any salary, we considered for them a wage equivalent to the minimum daily wage approved by the Iranian Ministry of Labor in 2022, taking into account that following the knee joint replacement surgery, they become unable to their daily routines (for instance, household chores).

On the other hand, the average salary designated by the Ministry in 2022 for Iranian employees was considered for employed patients. Moreover, considering the fact that the patient is usually accompanied by one of their family members when referring to medical centers, the costs incurred by the absence of the patient's companion from their workplace were also taken into account based on the minimum daily wage, the same as the one considered for the unemployed patients.

Also, from the sum of direct and indirect costs, the total costs per patient were estimated, and, finally, the total costs per patient were multiplied by the number of the study's sample to calculate the economic burden imposed on the sample investigated in this study. It should also be noted that Excel 2020 and Stata 20 were used to analyze the collected data.

Findings

Table 1 displays the demographic features of the study's participants, where the minimum, maximum, and

Table 1 The demographic features of the study's participants

Variable		*N* (%)
Gender	Female	271 (85.5)
	Male	29 (14.5)
Place of Residence	City (Percentage)	293 (96.5)
	Village (Percentage)	7 (3.5)
The Family Head	Yes (Percentage)	43 (21.5)
	No (Percentage)	257 (78.5)
Insurance Coverage	Yes (Percentage)	295 (97.5)
	No (Percentage)	5 (2.5)
Age	Mean (SD)	67.43 (8.54)
The Average Hospitalization Days	Mean (SD)	13.03 (4.33)

Table 2 The average direct medical costs in public and private sectors

The Type of Service	Governmental Sector	Private Sector	Percentage (%)
Visit	92.96	120.85	1
Surgery	1227.61	1595.89	12
Drug	207.28	269.46	2
Medical used supplies	6470.59	8411.77	64
Medical imaging	324.22	421.49	3
Hoteling	1578.19	2051.64	16
	176.02	228.83	2
Total	10076.87	13099.93	100

Table 3 Average non-medical costs

Type of Cost	Costs per year (in Dollars)	Percentage
Companion cost	467.12	0.41
Home Care	385.43	0.34
Travel cost	187.32	0.16
Time	83.76	0.09
Total	1123.63	100

average age of the studied patients were 50, 87, and 67.4 years old, respectively. Moreover, the minimum, maximum, and average hospitalization days were 4, 27, and 13.03, respectively.

Table 2 shows the direct medical costs of the services offered in public and private sectors individually, according to which the Medical used for treatment and hoteling constitute most of the medical costs, respectively. Artificial knee joints used in knee joint replacement surgery are very expensive and have allocated the largest share of costs in medical supplies. The cost of the private sector was estimated based on the tariffs of the private sector.

Table 4 Average annual direct medical and non-medical costs per patient

Type of Cost	Costs per year (in Dollars)	Percentage
Direct Medical Costs	83.76	0.89
Direct Non-Medical Costs	1123.63	0.11
Annual Direct Costs per Patient	1207.39	100

The average direct medical costs of the knee replacement procedure per patient were $10,076.87 and $13,099.93 in the public and private sectors, respectively.

Table 3 presents the direct non-medical costs. The average direct non-medical costs of knee joint replacement surgery are $1123.64, with companion costs constituting most of the direct non-medical costs. In this regard, the average companion costs were found to be $467.12 per patient.

According to Table 4, the average direct cost was $2414.29.

According to Table 5, direct and indirect costs per patient constituted 7.84 and 3.15% of the total costs of surgery for the study's participants, respectively. Moreover, the total annual costs per patient were found to be $13222.15. Finally, the economic burden of the knee joint replacement surgery was estimated at $67340417.28.

Discussion

In this study, the economic burden associated with knee joint replacement surgery in Iran was assessed. The results of the study indicated that the average direct medical costs per patient in public and private sectors were $10,076.87 and $13,099.93, respectively, while the average direct non-medical costs per patient were approximately $1123.64. These findings suggest a significant economic burden associated with knee joint replacement surgery in Iran.

Comparison of these results with previous studies reveals some differences. For instance, the study "cost-effectiveness of total knee arthroplasty in the United States" reported similar results in the Medicare population [24]. On the other hand, the study " Costs and models used in the economic analysis of Total Knee Replacement (TKR): A systematic review " focused on assessing the impact of knee joint replacement surgery on quality of life and employment and presented different outcomes [25].

Table 5 The economic burden of the knee joint replacement surgery in Iran

Cost ($)/ %	direct costs	Indirect costs		Total Cost	Number of patients	Economic burden
		Lost productivity	Lost labor			
Cost ($)	11200.51	500.61	37,979,560	1521.03	5093	67340417.28
%	84.7	3.8	11.5	100	-	

With the increasing rate of the life expectancy index and the decreasing rate of affliction with diseases in recent years which have been brought about due to rapid changes in human lifestyle, developing countries are experiencing the greatest increase in the burden of chronic diseases, which in turn, impose huge economic costs to the people and societies worldwide. The issue highlights the significance of caring the Iranian patients in need of knee joint replacement so that the disability caused by osteoarthritis of the knee and problems brought about by the disease is decreased.

The findings of the current study revealed that the knee joint replacement procedure imposes considerable costs on the patient, their family, and society. Considering the fact that the average age in the current study was 67.4 years (this age group falls within the epidemiology range of osteoarthritis), the replacement therapy becomes doubly important for the elderly, taking into account that the difficulty in walking and moving disturbs their performance of daily routines and causes depression.

It could thus be argued that replacing the knee joint can, in short term, significantly reduce the pain and improve the joint's function in patients suffering from osteoarthritis of the knee. Therefore, as the patients afflicted with osteoarthritis of the knee bear a significant financial burden, the surgery can be used as an effective method in increasing the patients' quality of life [30].

The results also suggested that the average direct medical costs of knee joint replacement procedure per patient were $10,076.87 and $13,099.93 in the public and private sectors, respectively. Based on the findings of this study, the contribution of direct costs and indirect costs are estimated at 84.7% and 15.3% of the total cost, respectively.

However, it should be noted the direct costs of treatment and care incurred by knee joint replacement surgery vary in different countries. For instance, a study carried out in the United States (2004) found that the direct and indirect costs constituted 37% and 63% of the surgery's costs, respectively. Furthermore, loss of patient's productivity, marginal costs of care, and other caregivers' costs covered 31%, 60%, and 9% of the surgery's indirect costs, respectively. Moreover, direct costs came to 1370.06 $ per patient per year: 341.78 $ was spent on hospitalization, 306.58 $ on diagnostic procedures (56% on visits and 44% on instrumental and laboratory tests), 214.16 $ on therapy (58% on physiotherapy and 42% on drugs), and 507.54 $ on non-medical costs (73% on salaries to temporary caregivers, 14% on transport, and 13% on auxiliary devices) [31].

Another study which was conducted in the U.S. revealed that direct medical costs, medication costs, and indirect costs of knee joint replacement surgery were $8601, S2941, and 4603, respectively. Moreover, a study carried out in Spain showed that the average total annual costs of knee osteoarthritis were €1502 per patient, out of which 86% belonged to direct and 14% to indirect medical costs, thus incurring considerable sums of money. The study also found that the worse the patient's health status was and the more severe their clinical symptoms were, the higher the incurred costs were [32].

In 2009, knee arthroplasty was the 14th leading cause of hospitalization in the United States, accounting for 22% of hospital admissions per 10,000 population [22]. Moreover, according to medical records collected from the hospitals of 28 American states, the highest portion of the disease's costs belonged to direct medical and non-medical costs.

Like most of the other studies, the current study also found that direct costs clearly constitute most of the total costs of knee joint replacement surgery. While some other studies have reported the same results, it is difficult to compare these kinds of studies with the ones showing the greatest share of the indirect costs in the total costs incurred by the surgery. In other words, individual, clinical, and health system differences undermine the comparison of the results found in different counties [32–35].

For instance, the average age of the investigated people was 67 years old in the current study, and therefore, most of the incurred costs belonged to direct costs. Furthermore, the variety of methods available for estimating the indirect costs makes the comparison of the studies' results a challenging issue. Considering the age and gender of the participants of the current study and the fact that 85% of them were female, the indirect costs constituted a limited amount of the total costs, as such participants were mainly unemployed.

On the other hand, the rate of knee joint replacement increases with an increase in the females' age and thus the reduction of bone tissue. Moreover, pregnancy and the decreased function of the ovaries during menopause precipitate the reduction of bone tissue, with many women replacing their knee joint when getting 60–70 years old [36].

Therefore, considering the huge costs of knee osteoarthritis treatment, it seems crucially important to identify and train the people who are at high risk of getting afflicted with the disease. For instance, organizing specific training programs is necessary to increase public awareness of the disease, so that they can take care of themselves against it and help reduce its prevalence rate [37–39].

Considering these differences and similarities, the results of the present study can assist policymakers and decision-makers in improving healthcare and economic policies. Furthermore, this research can guide future studies to investigate the economic burden of knee joint

replacement surgeries more comprehensively and propose better management strategies.

Furthermore, healthcare resources are required to be efficiently allocated to different parts of Iran. In this regard, the officials and decision-makers of Iran's healthcare system must be fully aware of the economic consequences of knee osteoarthritis. Therefore, physicians need to improve both the patients' clinical and social or economic consequences.

The diagnostic accuracy of osteoarthritis cases is one of the main strengths of the current study. In this regard, unlike the weak point of many COI studies, i.e., the confirmation of osteoarthritis based on the patient's report, in this study the cases of osteoarthritis were confirmed clinically.

Accurate calculation of the relevant costs is another strength of the present study. Accordingly, the direct and indirect costs of the disease were collected, including the costs incurred in both public and private sectors, which improves the validity of the costs' estimation.

According to the study's findings, the demand for replacing the knee joint is expected to considerably rise in the next decades, challenging the provision of related services.

Estimates indicate that the demand for total knee arthroplasty will increase, so that by 2030, total knee arthroplasty will increased in the United States 673%, UK 173%, and Wales 332% [14].

Therefore, increasing treatment costs may impose a heavy socioeconomic burden.

In summary, this study provides valuable insights into the economic burden of knee joint replacement surgery in Iran and can contribute to enhancing healthcare and economic policies in the country.

Conclusion

According to the study's results, it appears that despite the insurance coverage for knee joint replacement surgery in Iran, it still incurs enormous costs. Moreover, with the increasing number of elderly people in Iran, the rate of knee joint replacement procedure is expected to rise, increasing the surgery's costs and thus its economic burden for the Iranian public.

Limitation

There are limitations in economic burden studies .Small sample sizes or non-representative samples may limit the generalizability of the findings to broader populations. Insufficient or incomplete data, especially regarding healthcare costs, patient outcomes, and indirect costs, can impact the accuracy and reliability of the economic estimates. Poor data quality may also introduce bias into the analysis. Addressing these limitations involves rigorous study design, transparent reporting of methods and results, sensitivity analyses to assess the robustness of findings, and cautious interpretation of results in light of potential biases.

Author contributions

All authors contributed to the study conception, design, and preparation of the manuscript. NSH, A A, a participated in patient selection. AR, was involved in data acquisition and all author performed the statistical analysis and data interpretation.

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Data availability

Not applicable.

Code availability

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Declarations

Ethics approval

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Consent for publication

Not applicable.

Consent for participate

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Competing interests

The authors declare no competing interests.

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