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The Effect of Missed Opportunity to Routine Vaccination Coverage of Live Births and Surviving Infants in Kiribati Outer Islands

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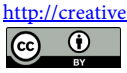

Abstract

This study examines the impact of missed opportunities for vaccination (MOV) on routine vaccination coverage and infant health outcomes in Kiribati's Outer Islands. Utilizing a cross-sectional survey design, the study surveyed 422 caregivers of children aged 0 - 23 months. The results revealed a significant disparity in vaccination coverage, with rural children 2.5 times more likely to miss vaccinations compared to their urban counterparts. The analysis also indicated that 53.3% of caregivers possessed poor knowledge of vaccination, which was strongly associated with higher MOV rates (AOR: 2.58, 95% CI: 1.55 - 4.25). The study underscores the need for targeted interventions, such as healthcare outreach in rural areas and caregiver education programs, to enhance immunization coverage. Addressing these gaps is essential to reduce the burden of vaccine-preventable diseases and decrease infant mortality in Kiribati's underserved Outer Islands.

Subject Areas

Public Health

Keywords

Missed Opportunities for Vaccination (MOV), Routine Vaccination, Infant Health, Kiribati Outer Islands, Vaccine-Preventable Diseases, Immunization Coverage, Caregiver Education, Rural Healthcare, Public Health Interventions, Infant Mortality, Healthcare Accessibility, Community, Outreach, Vaccine Awareness, Health Disparities, Pacific Island Nations

1. Introduction

Kiribati, a Pacific nation spanning 33 atolls across three geographically dispersed island groups (Gilbert, Phoenix, and Line), faces significant healthcare delivery challenges due to its vast oceanic territory. The Outer Islands, defined here as rural atolls outside South Tarawa, the urban capital, are particularly underserved, with limited access to health facilities and outreach services [1]. As of 2020, Kiribati's population was 119,000, with over half residing in South Tarawa, while the Outer Islands remain sparsely populated and reliant on intermittent healthcare access [2].

Immunization is a cornerstone of global child survival strategies, averting 4 - 5 million deaths annually among children under five [3]. Despite this, vaccine-preventable diseases (VPDs) such as measles and pneumonia persist in resource-limited settings like Kiribati's Outer Islands, where logistical barriers and caregiver knowledge gaps exacerbate low coverage [4]. A critical yet understudied factor contributing to these gaps is the prevalence of Missed Opportunities for Vaccination (MOV), defined as instances where eligible children interact with health services but fail to receive due vaccines [5]. Globally, MOV accounts for 15% - 30% of under-vaccination in low-income countries, yet data from Pacific Island nations remains scarce [6].

In Kiribati, the national immunization schedule includes nine vaccines delivered at six contact points (birth, 6, 10, and 14 weeks, 9 months, and 18 - 23 months) [7]. However, coverage disparities persist, with Outer Islands reporting 20% - 30% lower full immunization rates compared to South Tarawa [8]. Prior studies in similar contexts (e.g., Vanuatu, Solomon Islands) link MOV to rural residence, low parental education, and fragmented health communication [9] [10], but Kiribati-specific evidence is lacking. This study addresses this gap by quantifying MOV prevalence, identifying risk factors, and proposing context-specific interventions to improve coverage in the Outer Islands.

2. Methodology

2.1. Study Area

The Republic of Kiribati, located in the Micronesia subregion of Oceania (see **Figure 1**), consists of 32 atolls and one raised coral island (Banaba), spread across three island groups: Gilbert, Phoenix, and Line Islands. The country has a total land area of 811 km^2, dispersed over 3.44 million km^2 of ocean, making healthcare access a critical challenge. As per the 2020 census, Kiribati has a population of over 119,000, with more than half residing in South Tarawa, the capital. The Outer Islands, which are more remote, face significant healthcare access issues, making them the focus of this study [11].

2.2. Study Design

This study employed a cross-sectional design, utilizing both quantitative and qualitative methods to analyze missed opportunities for vaccination (MOV) and its effects on infant survival rates in Kiribati's Outer Islands.

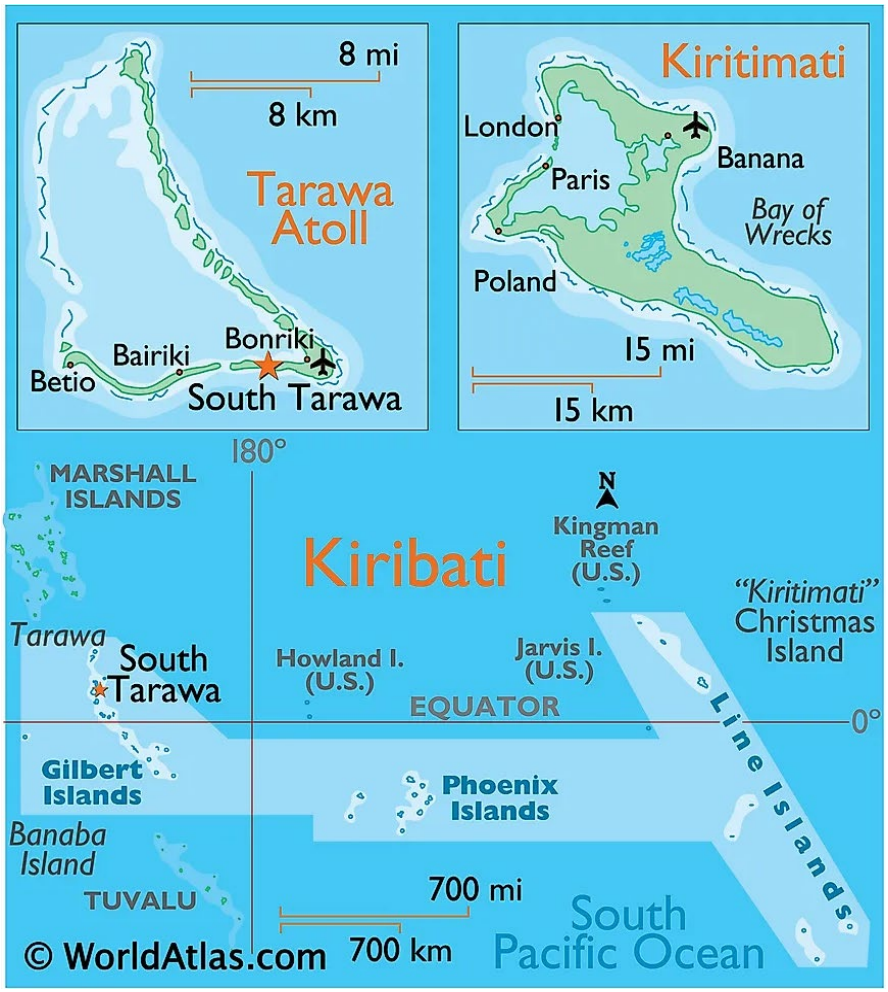

Figure 1. Map of Kiribati. (Source: https://www.worldatlas.com/maps/kiribati)

2.3. Study Population

The study targeted children aged 0 - 23 months and their caregivers residing in Kiribati's Outer Islands. The sample size (n = 422) was determined based on:

The estimated prevalence of MOV,

A 95% confidence level, and

A margin of error of 5%.

A multistage cluster sampling technique was used to select study participants, ensuring geographical representation across the Outer Islands.

The multistage cluster sampling method involved:

Stage 1: Selecting Outer Islands randomly from each of the three island groups (Gilbert, Phoenix, and Line).

Stage 2: Dividing each island into clusters (communities or villages) based on population size.

Stage 3: Randomly selecting households within each cluster that had eligible children (0 - 23 months) and willing caregivers.

Rationale for age range: Children 0 - 23 months were targeted because this

aligns with Kiribati's immunization schedule, which concludes with the final measles-rubella dose at 18 - 23 months [7].

2.4. Data Collection

Data was collected using three tools:

Structured Questionnaire: Administered face-to-face in Gilbertese, it included:

i. Demographics: Caregiver age, education, marital status, occupation.

ii. Vaccination History: Verified using health records or caregiver recall (for non-documented cases).

iii. MOV Assessment: Defined as *a child eligible for vaccination during a healthcare visit who did not receive* ≥ 1 *required dose without contraindication* [6].

iv. Knowledge Assessment: 8 questions (e.g., "*Name three diseases prevented by vaccines*"), scored 0 - 21 (Cronbach's $\alpha = 0.78$).

v. Attitude Assessment: 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) for 8 items (e.g., "*Vaccines are safe*").

Health Record Review: Cross-checked vaccination dates against the national schedule.

Qualitative Interviews: 15 caregivers participated in semi-structured interviews exploring barriers to vaccination (e.g., "*What challenges do you face in accessing clinics*?").

Pre-testing: Tools were piloted on 30 caregivers in South Tarawa and refined for clarity.

3. Measurements

3.1. Missed Opportunity for Vaccination

A MOV is a child aged 0 to 23 months who comes to the health facility for health services with a recommended time range of immunization and does not receive any of the vaccines (one or more) without a contraindication for that vaccine on the day of the assessment. The MOV was calculated using the child's birth date, interview date, and the Kiribati national immunization schedule, which has six contact points: at birth, 6th weeks, 10th weeks, 14th weeks, 9 months, and 18 months up to 23 months of life [6].

3.2. Knowledge of Immunization

Participants were asked eight knowledge-related questions, with a possible score ranging from zero to twenty-one. A score of 1 was assigned if the parents/caretakers correctly answered the given question, and a score of 0 if they did not. Those who scored the mean or higher were considered to have good knowledge, while those who scored below the mean were considered to have poor knowledge.

3.3. Attitude towards Immunization

Eight Likert-scaled question items were used to assess attitudes. Each question

item has a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Participants could choose between five possible response categories for each statement based on a five-point Likert scale: "Strongly agree", "agree", "neutral", "disagree" and "Strongly disagree". Participants who scored at or above the mean were considered to have a favorable attitude, while those who scored below the mean were considered to have an unfavorable attitude.

3.4. Contraindication for Vaccination

Previous vaccine reactions such as convulsion, anaphylaxis, shock, and encephalopathy soon after or within three days of DPT vaccine injection, or children who developed anaphylaxis after measles immunization or convulsion after hepatitis B immunization, or if the child is symptomatic HIV/AIDS infected.

4. Data Analysis

Descriptive and inferential statistics are used to analyze data. Descriptive statistics are used to summarize the study variables' characteristics and frequencies. Completed questionnaires were cleaned, coded, and entered EPI data statistical software version 4.6.1 before being exported to SPSS version 26 for analysis. To describe the study population with relevant variables, frequencies, proportions, and summary statistics were used. To identify candidate variables for multivariable analysis, bivariate analysis was used. Variables with p-values less than 0.25 in bivariate analysis were entered into multivariable logistic regression. Finally, for the strength of the associations, a significant association was determined at p-value 0.05 using the Adjusted Odds Ratio with 95% CI.

4.1. Ethical Considerations

Ethical approval was obtained from Kiribati Ministry of Health and Medical Service, before conducting the study. Informed consent was also obtained from all the study participants or their guardians. Confidentiality and anonymity were ensured throughout the study process. The study results are disseminated to the stakeholders and the public in an appropriate manner.

4.2. Results

A total of 422 caregivers participated in the study, achieving a 100% response rate. More than half of the children (52.1%) were male, and the majority (73.7%) were aged 0 - 11 months. Most children (94.1%) were born in a health facility, and 96.9% of mothers attended at least one antenatal care visit.

These findings indicate that most children were brought to health facilities by their mothers, and the majority of caregivers had only primary school education (61.4%). Caregiver education, occupation, and marital status may influence routine vaccination coverage and missed opportunities for vaccination (MOV). (See Table 1)

Table 1. Socio-demographic characteristics of study children and caregivers.

Variable	Category	Frequency (n)	Percentage (%)
Age of Child (months)	0 - 11	311	73.7%
	12 - 23	111	26.3%
Gender of Child	Male	220	52.1%
	Female	202	47.9%
Person Bringing Child	Mother	412	97.6%
	Father	6	1.5%
	Caregiver	4	0.9%
Place of Birth	Home	25	5.9%
	Health Facility	397	94.1%
Antenatal Care (ANC) Attendance	Yes	409	96.9%
	No	13	3.1%
Educational Level of Caregivers	No formal education	9	2.1%
	Primary school	259	61.4%
	Secondary school	100	23.7%
	College and above	54	12.8%
Occupational Status of Caregivers	Housewife/Farmer	187	44.3%
	Daily laborer	25	5.9%
	Government/Private Employee	185	43.8%
	Student	25	6.0%
Marital Status	Married	389	92.2%
	Single	4	0.9%
	Divorced/Separated	24	5.7%
	Widowed	5	1.2%

Table 2. Caregiver-related factors influencing MOV.

Variable	Category	Frequency (n)	Percentage (%)
Knowledge about Immunization	Good	197	46.7%
	Poor	225	53.3%
Attitude toward Immunization	Favorable	261	61.8%
	Unfavorable	161	38.2%
Decision-Maker for Child Vaccination	Father	33	7.8%
	Mother	46	10.9%
	Another Relative	2	0.5%
	Both Parents Jointly	341	80.8%

vaccination. The study found that 53.3% of caregivers had poor knowledge about immunization, and 38.2% had an unfavorable attitude toward vaccination. Most vaccination decisions (80.8%) were made jointly by both parents, while 7.8% were made by fathers alone.

These results highlight the need for targeted health education programs to improve caregiver knowledge and attitudes toward vaccination. (See Table 2)

Table 3 presents the results of both bivariate and multivariable logistic regression analyses, examining factors associated with missed opportunities for vaccination (MOV) among children aged 0 - 23 months in health facilities in Kiribati. The analysis includes crude and adjusted odds ratios (COR and AOR) with corresponding 95% confidence intervals (CI) for each factor.

Table 3. Bivariate and multivariable logistic regression output for the factors associated with MOV among children 0 - 23 months at health facilities in Kiribati.

Variables	Categories	Missed opportunity		COR (95%CI)	AOR (95%CI)
		Yes (%)	No (%)		
Birth order	1	50 (36.20)	88 (63.80)	1	1
	2 - 3	68 (37.20)	115 (62.80)	0.96 (0.60 - 1.50)	1.02 (0.55 - 1.81)
	4+	56 (55.40)	45 (44.60)	1.78 (1.01 - 2.91)	0.72 (0.35 - 1.40)
Educational status	No formal education	82 (67.20)	40 (32.80)	6.48 (2.89 - 14.60)	
	Primary	45 (28.5)	113 (71.50)	1.30 (0.59 - 2.90)	0.79 (0.29 - 2.05)
	Secondary	28 (27.50)	74 (72.50)	1.12 (0.00 - 2.58)	0.89 (0.32 - 2.40)
	College and above	12 (25.50)	35 (74.50)	1	1
Marital status	Married	148 (38.00)	241 (62.00)	1	1
	Single/divorced/ Separated/widowed	20 (64.50)	11 (35.50)	2.85 (1.32 - 5.98)	3.77 (1.48 - 9.52)
Place of residence	Urban	113 (32.90)	230 (67.10)	1	1
	Rural	53 (69.70)	23 (30.30)	5.05 (2.95 - 8.71)	2.54 (1.30 - 4.97) *
Knowledge	Good knowledge	50 (25.50)	146 (74.50)	1	1
	Poor knowledge	119 (52.40)	108 (47.60)	3.22 (2.05 - 4.68)	2.58 (1.55 - 4.25) **
Attitude	Favorable attitude	91 (35.10)	168 (64.90)	1	1
	Unfavorable attitude	77 (47.80)	84 (52.20)	1.68 (1.80 - 2.42)	1.45 (0.86 - 2.30)
vaccination status not Screened	Yes	32 (18.30)	143 (81.70)	5.12 (3.23 - 8.08)	2.98 (1.60 - 5.35) **
	No	137 (54.80)	113 (45.20)	1	1
Information seen or heard in the last months	Yes	38 (18.20)	171 (81.80)	1	1
	No	120 (56.30)	93 (43.70)	4.09 (2.68 - 6.21)	2.38 (1.32 - 4.07) *

*Statistically significant association at p-value < 0.05, **statistically significant association at p < 0.001, COR = Crude odds ratio, AOR = Adjusted odds ratio.

Birth Order

The birth order of a child significantly affects the likelihood of missed vaccination opportunities. In this study, children born fourth or later had a higher likelihood of MOV compared to firstborns (COR: 1.78). This trend is consistent with findings by Adeyinka, Oladimeji, Adekanbi, Adeyinka, Falope, and Aimakhu [12] who found out that in Nigeria higher birth order was associated with reduced vaccination uptake, with parents often prioritizing older siblings or experiencing difficulties managing the needs of multiple children. However, after adjusting for other factors, the significance of birth order diminishes (AOR: 0.72), indicating that factors such as family size, socio-economic status, and parental knowledge play a larger role.

Educational Status of Caregivers

Caregivers' educational status emerged as a key determinant of MOV. In this study, caregivers with no formal education were significantly more likely to have children with MOV (COR: 6.48). This finding mirrors global trends, where education is consistently linked to better healthcare outcomes, including vaccination rates. A study in Eritrea by Kibreab, Lewycka and Tewelde [13] similarly reported that higher education levels among mothers were associated with improved immunization rates, as educated caregivers are more likely to understand the importance of vaccines and access health services. As education increases, the odds of MOV decrease, reinforcing the protective role of education in vaccination efforts.

Marital Status of Caregivers

Marital status was another important factor influencing MOV. Caregivers who were single, divorced, separated, or widowed had significantly higher odds of MOV compared to their married counterparts (AOR: 3.77). This finding aligns with research by Olwanda *et al.* [14] in Kenya, which shows that single caregivers faced greater challenges in accessing health services, often due to reduced socio-economic resources and support systems. The absence of a partner may limit the ability to attend vaccination appointments or prioritize healthcare for children.

Place of Residence

Geographic location plays a crucial role in access to vaccination services. In this study, children living in rural areas had significantly higher odds of experiencing MOV compared to those in urban areas (AOR: 2.54). The findings align with that of Geta, Wakjira, & Hailu [15] who reported that rural residence in Ethiopia is consistently linked with lower vaccination coverage due to factors such as distance to health facilities, lack of transportation, and limited availability of healthcare services which highlights the need for targeted outreach and mobile vaccination services in rural areas to bridge the access gap.

Knowledge of Vaccination

Poor knowledge about vaccination was strongly associated with MOV in this study (AOR: 2.58). Lack of awareness about vaccine schedules, the diseases vaccines prevent, and the importance of timely immunization is a well-documented barrier to full vaccination coverage. A study in Nigeria by Madubueze *et al.* [16]

found that poor maternal knowledge was a major factor in missed vaccinations, emphasizing the importance of health education campaigns to improve vaccine awareness and uptake.

Attitude Towards Vaccination

In the bivariate analysis, caregivers with unfavorable attitudes toward vaccination were more likely to have children with MOV (COR: 1.68). However, this association weakened in the adjusted model (AOR: 1.45), becoming statistically insignificant. This finding suggests that while attitudes are important, they may not be as influential in determining vaccination outcomes when other factors such as education, knowledge, and access to healthcare are accounted for. A similar pattern was observed in a study from Ghana in a study by Bam *et al.* [17], where initial negative attitudes toward vaccination were mitigated when caregivers received more information and support from healthcare workers.

Vaccination Status Not Screened

Children whose vaccination status was not routinely checked during health facility visits had significantly higher odds of MOV (AOR: 2.98). This finding is consistent with global evidence showing that regular screening and tracking of vaccination status are critical in ensuring timely vaccinations. A study by Kaboré *et al.* [18] in Burkina Faso highlighted that children whose vaccination status was not checked during healthcare visits were more likely to miss their next scheduled vaccine, reinforcing the need for health workers to actively monitor and document vaccination progress.

Information Received Regarding Vaccination

Caregivers who had not received any vaccination-related information in the last three months were more likely to have children with MOV (AOR: 2.38). Consistent, timely communication about vaccination schedules and the importance of vaccines is crucial for improving coverage. Research by Obi-Jeff *et al.* [19] in Nigeria showed that regular communication between healthcare providers and caregivers, including SMS reminders and community outreach, significantly improved vaccination rates. This finding suggests that improving communication efforts in Kiribati, particularly in rural areas, could substantially reduce MOV.

4.3. Discussion

This study examined missed opportunities for vaccination (MOV) among children aged 0 - 23 months in Kiribati's Outer Islands, highlighting key socio-demographic and caregiver-related factors that influence routine immunization coverage. The findings indicate that MOV is prevalent (52.4%), with rural children, those from single-parent households, and those whose caregivers had limited education or knowledge about vaccination being most affected.

Comparison with Previous Studies

The 52.4% MOV prevalence found in this study aligns with similar studies in low-resource settings. For example, research in Ethiopia reported an MOV prevalence of 55%, while a Kenyan study found 47% [15] [20]. These figures suggest that geographical and socio-economic barriers play a significant role in vaccina-

tion access across different regions.

Key Determinants of MOV

Caregiver Education and Knowledge

Caregiver education emerged as a strong determinant of MOV. Children whose caregivers had no formal education were 6.48 times more likely to experience MOV (AOR = 6.48, $p < 0.001$). This aligns with previous studies in Nigeria and Eritrea, which found that caregivers with higher education levels had better immunization uptake [12] [13]. Limited education reduces awareness of vaccine schedules, the importance of timely immunization, and the ability to navigate healthcare services.

Marital Status and MOV

Children from single, divorced, or widowed caregivers were nearly four times more likely to experience MOV (AOR = 3.77, $p = 0.004$). Similar findings in Kenya and Ghana indicate that single caregivers face challenges in accessing healthcare services, often due to financial constraints or lack of spousal support in decision-making [17] [20]. This highlights the need for targeted interventions to support single caregivers, such as flexible immunization schedules and mobile vaccination units.

Rural Residence and MOV

Children in rural areas had a significantly higher MOV rate (69.7%) compared to urban areas (32.9%). Rural residents doubled the odds of MOV (AOR = 2.54, $p = 0.006$), reinforcing longstanding evidence that geographical barriers limit access to routine immunization services [17]. Studies in Ethiopia and Nigeria found similar rural-urban disparities due to long travel distances, poor infrastructure, and healthcare worker shortages [15] [16]. Expanding health outreach services in Kiribati's remote islands could help reduce these disparities.

Lack of Screening during Health Visits

Children whose vaccination status was not checked during healthcare visits had nearly three times the odds of MOV (AOR = 2.98, $p < 0.001$). This aligns with a Burkina Faso study showing that routine screening at health visits significantly improves vaccination rates [18]. Training healthcare workers to integrate vaccination screening into all child health visits could substantially reduce MOV rates.

Lack of Recent Vaccination Information

Caregivers who had not received vaccination-related information in the last three months were twice as likely to have children with MOV (AOR = 2.38, $p = 0.004$). This supports evidence from Nigeria, where SMS reminders and community outreach programs significantly improved vaccine uptake [21]. Strengthening health communication efforts in Kiribati, particularly through radio, SMS alerts, and community engagement, could enhance caregiver awareness and reduce MOV.

5. Conclusion and Recommendation

The study highlights significant gaps in routine vaccination coverage among live

births and surviving infants in Kiribati's Outer Islands, primarily due to missed opportunities for vaccination (MOV). Key factors contributing to MOV include caregivers' educational status, marital status, place of residence, knowledge about vaccination, and access to health information. Children from rural areas, born to single or less-educated caregivers, or those whose caregivers had limited knowledge about vaccination were more likely to experience MOV. This gap in vaccination coverage leaves infants vulnerable to preventable diseases and underscores the need for targeted interventions to improve immunization rates and reduce infant mortality in the region.

Several measures are recommended to address these gaps. First, community-based health education programs should be implemented to enhance caregiver knowledge of vaccination schedules and their importance. In rural and less-educated populations, these programs are critical to ensuring caregivers understand the benefits of timely immunization.

Second, healthcare outreach services in the Outer Islands should be expanded, with mobile vaccination units introduced to reach remote areas where access to healthcare is limited. Regular screening and documentation of vaccination status during all healthcare visits is also essential to ensure that missed vaccines are identified and catch-up services are provided.

Additionally, communication efforts must be strengthened through SMS reminders, radio broadcasts, and community outreach programs to ensure caregivers receive timely information about vaccination schedules. Encouraging joint decision-making between parents regarding child immunization, particularly involving fathers, can also increase vaccine uptake.

By addressing these factors, Kiribati can achieve higher routine vaccination coverage, reduce the occurrence of missed opportunities, and improve infant health outcomes, particularly in its more isolated Outer Islands.

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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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