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Vitamin A supplementation and estimated number of averted child deaths in Ethiopia: 15 years in practice (2005–2019)

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Abstract

Vitamin A supplementation (VAS), started as a short-term strategy pending dietary improvements, has been implemented in Ethiopia for the last 15 years. We aimed to describe the trends in VAS coverage and estimated the associated reductions in child mortality. VAS coverage data obtained from the District Health Information System and the Demographic and Health Surveys were linked to child mortality data from the United Nations Interagency Group for Child Mortality Estimation (UN IGME). The number of child deaths averted was modelled assuming 12% and 24% reductions in all-cause mortality. From 2006 to 2011, VAS was delivered through campaigns, and coverage was above 85%. However, from 2011 onwards, VAS delivery was integrated to the routine health system, and the coverage declined to <60% with significant disparities by wealth quintile and rural–urban residence. VAS has saved between 167,563 to 376,030 child lives (2005–2019), but additional lives (>42,000) could have been saved with a universal coverage (95%). Inconsistent supply of vitamin A capsules, but more importantly, low access to health care, and the limited contact opportunities for children after 24 months may have contributed to the declining VAS coverage. Any changes in target or scale-up should thus consider these spatial and socioeconomic variations. Increasing the coverage of VAS and closing the equity gap in access to nutrition services is critical. However, with alternative programmes like vitamin A fortification being set-up, the benefits and safety of VAS need to be closely monitored, particularly in areas where there will be overlap.

KEYWORDS
equity, health system, mortality, vitamin A supplementation

1 | INTRODUCTION

Vitamin A deficiency (VAD) is believed to be one of the most widespread nutrient deficiency in low- and middle-income countries (LMIC; World Health Organization, 2009). Despite limited number of national surveys that estimate the magnitude of vitamin A deficiency, the low dietary diversity, often characterized by limited consumption of vitamin A-rich fruits, vegetables and animal source foods, is likely to contribute to VAD in LMIC (de Pee, West, Hautvast, Muhilal, & West, 1995). Besides, both acute and chronic inflammation/infection has been linked to increased utilization and excretion of vitamin A, further contributing to the aetiology of VAD (World Health Organization, 2009), whereas increased vitamin A intake is in-turn linked to reduced morbidity and mortality from infectious diseases (Beaton et al., 1993; Stevens et al., 2015).

Consequently, Vitamin A supplementation (VAS) programmes have been designed and implemented since the 1990s and have now reached more than 80 countries worldwide. VAS include semiannual delivery of two doses of 200,000 IU of vitamin A to children 1–5 years of age, and one dose of 100,000 IU for infants 6–11 months (World Helath Oragnization, 2011). In many countries that have scaled-up VAS, critical information, such as vitamin A intake and status, needed to appropriately target, scale-up or scale-back interventions are not available (Wirth et al., 2017). Moreover, in recent years, the potential benefit of VAS in reducing VAD and child mortality has been questioned (Benn et al., 2015; Mason, Greiner, Shrimpton, Sanders, & Yukich, 2015). Many factors including the magnitude of infectious disease (e.g. diarrhoea and measles), VAD and immunization can affect outcomes (Benn et al., 2015). The dosage, timing, age and sex of the child can also modify the effect of VAS on mortality (Benn et al., 2015).

With increasing number of countries adopting fortification of foods with vitamin A, the decline of the burden of infectious disease, increased immunization and the inconsistent supply of vitamin A capsules that are mainly donor-supported has made the debate over the if and when to scale-back of VAS programmes timely (Bhutta & Baker, 2015; Greiner, Mason, Benn, & Sachdev, 2019; Raiten et al., 2020). The controversies related to VAS have highlighted several knowledge and data gaps. We aimed to contribute to filling this gap by evaluating the coverage and effectiveness of the VAS programme in reducing child mortality.

The prevalence of night blindness (condition making it difficult or impossible to see in relatively low light) in Ethiopia decreased significantly over the last 15 years from 4.2% to 0.8% among preschool children, hence shifting from a moderate to a mild public health problem (Sahile et al., 2020). The country has also witnessed a remarkable economic growth, but this has not translated into improved diets. The quality of young children's (6–24 months) diets remains a concern, since only in 2016, less than 10% of children met the minimum acceptable diet (Ethiopian Public Health Institute & Inner City Fund, 2016). Therefore, evaluating the VAS programme of Ethiopia on child mortality provides a unique opportunity as the VAS programme has been implemented for the last 15 years, and although vitamin A fortification, although planned, has not been implemented yet, dietary diversity remains very low and biofortified crops are not commonly available. Therefore, estimates of mortality reductions are less likely to be confounded by alternative vitamin A programmes. This manuscript describes the performance of 15 years of vitamin A supplementation in Ethiopia and assesses the lives saved through its implementation.

Key messages

- Over the last 14 years (2005–2018), at least three quarters of the targeted population received at least one dose of vitamin A.
- Inequalities in VAS coverage persist due to low access to health care.
- VAS programme has contributed to substantial reductions in child death in Ethiopia, despite a declining coverage; 167,563 to 376,030 child lives were saved between 2005 and 2019.
- The high rates of VAS-sensitive mortalities support the scale-up of VAS.

2 | METHODS

2.1 | Data and coverage

The 2000, 2005, 2011 and 2016 rounds of the Ethiopian Demographic and Health Surveys were used to calculate the coverage of VAS and albendazole by wealth quintile and urban/rural residence (Ethiopian Public Health Institute & Inner City Fund, 2000, 2005, 2011, 2016). Albendazole is almost always provided along with vitamin A supplements for children aged 24–59 months. Therefore, the coverage of albendazole was used to validate the accuracy of VAS coverage. The DHS surveys are nationally representative and collect information on household demographic and socioeconomic characteristics and on vitamin A supplementation over the last 6 months. The surveys were based on stratified samples selected at two stages, and each reporting domain was disaggregated by rural–urban residence. The health monitoring data collected by the health worker was obtained from the Health Monitoring Information system (HMIS), and since 2016, this was obtained from the District Health Information System (DHIS2) of the Ethiopian Federal Ministry of Health. The yearly coverage of VAS and albendazole (number of capsules administrated to the targeted population by the health worker) was obtained from the DHIS2 (see Data S1). The proportion of children that has taken one or two dose of vitamin A or albendazole supplementation was calculated. Child mortality data were taken from the United Nations Interagency Group for Mortality Estimation (2020). The UN IGME led by United Nations Children's Fund [UNICEF], including the World Health Organization, the World Bank and the United Nations Population Division of the Department of Economic and Social Affairs, produces estimates of child and young adolescent mortality annually, reconciling differences across data sources and screening for data quality.

2.2 | Estimations of mortality and lives saved

We calculated the mortality rate and the number of child deaths in the presence and absence of VAS. The number of deaths that would have been averted, if near universal coverage of 95% was achieved, was calculated. The model linked the VAS coverage to reductions in mortality using the following equation:

$$\text{Coverage change} \times \text{effectiveness} \times \text{affected proportion} = \text{Impact}$$

More details about the basic calculations are presented in Tables S1 and S2. The model assumed two scenarios using VAS-related mortality reductions of 24%, based on the meta-analysis of Mayo-Wilson, Imdad, Herzer, Yakoob and Bhutta (2011) or a much lower mortality reductions of 12% as argued by Mason, Greiner, Shrimpton, Sanders and Yukich (2015) and Raiten et al. (2020). In a Cochrane Systematic Review published by Imdad, Mayo-Wilson, Herzer and Bhutta (2017), a 24% reduction in all-cause mortality was reported. The addition of the Deworming and Enhanced Vitamin A Supplementation Trial was argued to cut by half (12%) the reduction in all-cause mortality. In light of this heterogeneity, and the true value expected to be anywhere between 12% and 24%, we have used these two scenarios to estimate the mortality reductions.

3 | RESULTS

The distribution of VAS was first started in 2004 in four drought prone regions and by 2006 has become a national strategy delivered through biannual campaigns: (i) enhanced outreach services (EOS)[1] and (ii) Child Health Days (CHDs)[2] (Table 1). The implementation of the VAS programme has evolved over the years. The programmes implemented in EOS were transitioned to delivery through CHDs, and later was gradually integrated with the routine health services. Routinely, every child aged 6–59 months would receive, twice a year, vitamin A supplement during contacts at the health post.

The annual VAS coverages of at least one or two capsules per year are presented in Figures 1 and 2, respectively. Over the 15 years of implementation, coverage rates of children receiving at least two capsules of vitamin ranged from 41% to 93% (Figures S1 and S2). During the first years of the initiative (2006–2011), the VAS coverage was above 85% but has since declined to reach coverage levels <70% for one dose and <60% for two doses of VAS per year (Figures S1 and S2). However, over the last 14 years (2005–2018), at least 75% of the targeted population received at least one dose of vitamin A. Similar trends than VAS were observed for the coverage of albendazole (Figure 1).

As shown in Figure 2, inequities by wealth and rural–urban residence remained the same over the 2000 to 2016 period. For example, the VAS coverage difference between the richest and the poorest wealth quintile only changed by one percentage point between the 2005 and the 2016 DHS rounds (15.9% vs. 16.9%). Similar trends were observed by rural–urban residence over the period of 2000–2016 as reflected by the lower coverage of VAS in rural and remote areas.

[1]The Enhanced Outreach Strategy (EOS) is a programme consisting of three child survival initiatives: vitamin A supplementation, deworming, and screening and referral of malnourished children and malnourished pregnant and lactating women to the targeted supplementary feeding programme.

[2]The Child Health Day: The CHD is a similar modality as that of the EOS except that campaigns are organized at kebele level. The CHD is considered as a transitional stage to the ultimate integration of VAS into the Health Extension Programme.

TABLE 1 Timeline of vitamin a supplementation implementation in Ethiopia

Year	Topic
2004	The enhanced outreach strategy started in four drought prone region. The mobile teams went from local to local in order to provide vitamin A capsule, deworming and nutrition screening in twice-yearly campaigns
2006	The whole country was considered for the vitamin A capsule
2008	The community based nutrition (CBN) was launched with the aim to shift gear from facility-based approach to community platform. It started with 228 districts and then was scaled-up
2012	First districts transiting from campaign modality into routine health extension programme
2013	Districts where child health days (CHDs) were well-established transitioned fully from the CHD model to use of routine services, and urban districts began to transition from enhanced outreach strategy (EOS) directly to use of routine services
2015/2016	El Nino-induced drought that overburden the health system with more severe cases of health treatment and jeopardized preventive nutrition services included vitamin A
2017/2018	Focus on routine service for vitamin A except for Somali and Gambella regions that remained through enhanced outreach strategy

The child mortality rate has steadily declined between 2005 and 2019. The calculated mortality reductions related to VAS as well as the coverage has slightly decreased over the years. We estimated that a total of 167,563 to 376,030 child lives were saved between 2005 and 2019 (Figures 3 and 4). Depending on the assumed reduction in mortality, the national VAS programme could have saved an additional 42,571 to 106,299 child death in Ethiopia if the VAS coverage reached 95% (Figure 4). We have estimated that if the coverage continues to stay around 50% in 2020/2021 or even decrease to 30%, the programme will miss the opportunity to avert an estimated 5592 to 20,422 child death over the next 2 years.

4 | DISCUSSION

We evaluated the coverage of VAS during the 15 years of implementation in Ethiopia and estimated its effect on child mortality. Our study illustrates that the coverage of VAS as well as the overall child mortality has been declining in the past 15 years. Inequalities in the coverage of VAS by wealth quintile and rural–urban residence persisted, questioning the equitability of the access of nutrition services through the health system. Despite the shortcomings in implementation, the VAS programme is estimated to have saved 167,563 to 376,030 child deaths between 2005 and 2019. Started as a short-term strategy pending dietary improvements, VAS has now been

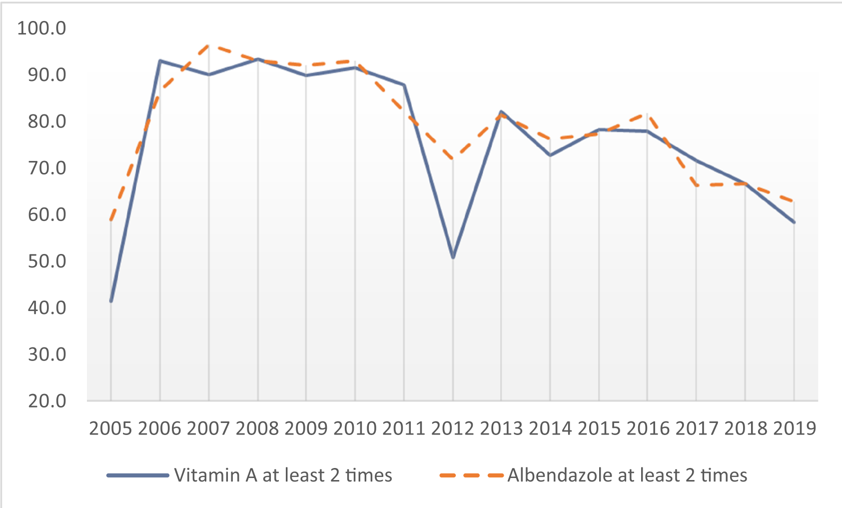

FIGURE 1 Trends of vitamin A and albendazole received at least two times each year in Ethiopia, 2005 to 2019

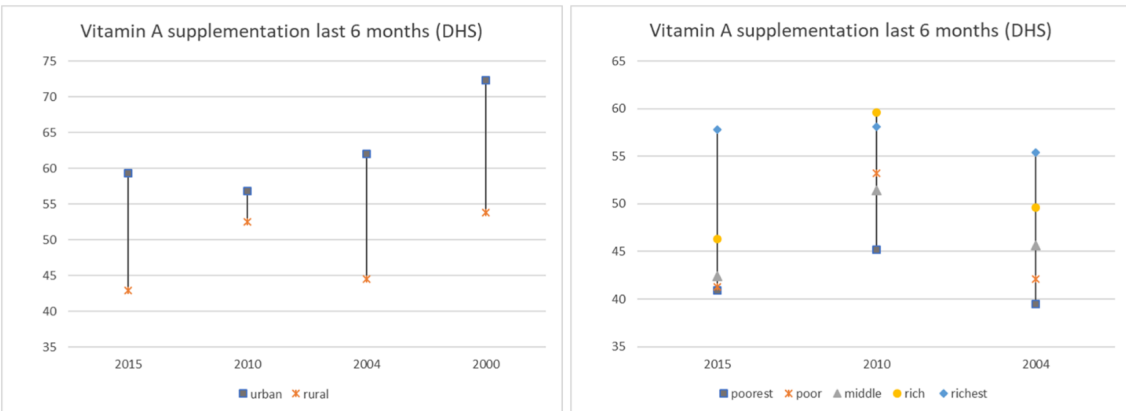

FIGURE 2 Prevalence of children receiving over the last 6 months a capsule of vitamin A in the four Ethiopian demographic health surveys according to their residence of living (left figure) and their social characteristics (right figure)

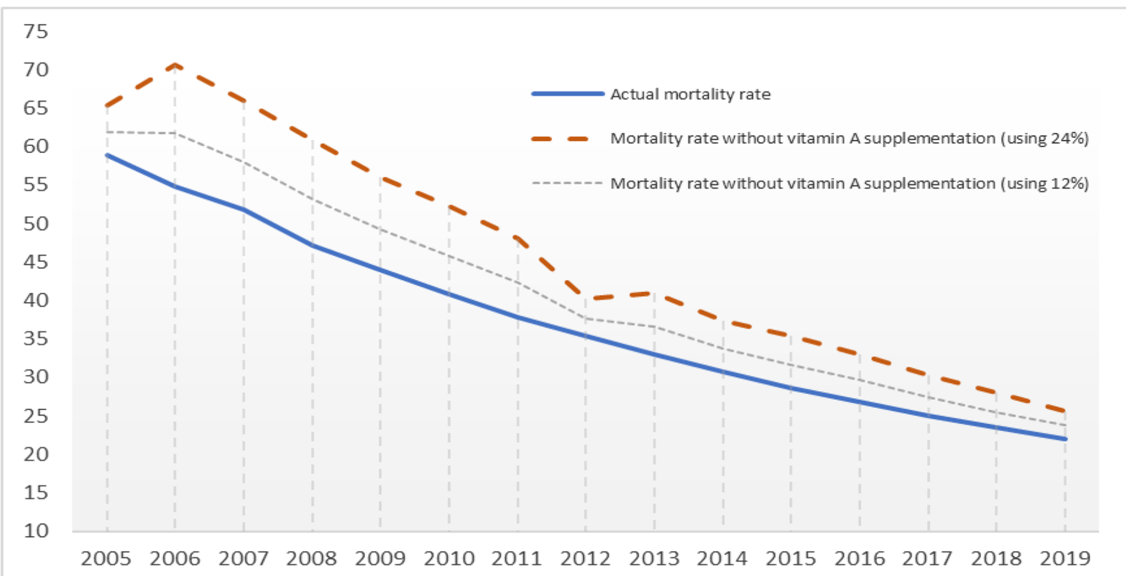

FIGURE 3 Estimated mortality rates in the presence and absence of preventive vitamin A supplementation among children aged 6–59 months (assuming a 12% or 24% mortality due to vitamin A), 2005 to 2019

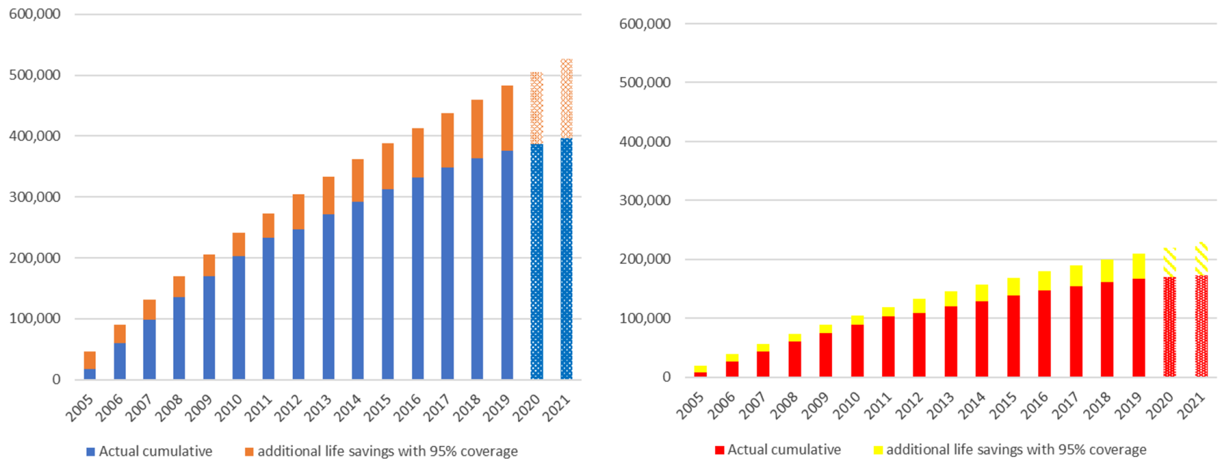

FIGURE 4 Annual child deaths averted assuming 24% (left) and 12% (right) mortality reductions attributed to by vitamin A supplementation, Ethiopia, 2005–2019

operational since the 1990s and has expanded to more than 80 countries (Latham, 2010). In Ethiopia, the programme was started in the early 2000s (Demissie, Ali, Mekonen, Haider, & Umeta, 2010) and has been operational for the last 15 years. During these years, the implementation modality has evolved from a delivery through campaigns (CHDs) to a provision through routine health systems (Gatobu et al., 2017). Yet, in line with global trends (United Nations Children's Fund, 2018), coverage of VAS in Ethiopia has been on a steady decline. This is in line with observations from other sub-Saharan African countries, where close to two-thirds of VAS programmes have become inactive and coverage was only 64% in UNICEF's priority countries in 2018 (United Nations Children's Fund, 2018). The reliability of supply, inefficiencies in implementation and the increased implementation of alternative food-based vitamin A interventions (e.g. fortification) may partly explain this global trend. Further decline in VAS coverage due to the novel corona virus pandemic (COVID-19) could further lead to missed opportunities in averting child deaths.

In Ethiopia, vitamin A fortification and biofortification programmes have not been operational at scale, and diets remain low in vitamin A-rich foods (Ethiopian Public Health Institute & Inner City Fund, 2016). Although inconsistencies in the supply of vitamin A capsules are still possible, a key challenge explaining the low and declining coverage of VAS is the low access to health care, particularly among the poorest wealth quintiles and the remote rural areas. The health extension programme in Ethiopia has helped improve access and coverage of health services to the rural poor (Medhanyie et al., 2012), but several nutrition services can be scaled-up to maximize impact on child health and well-being (Baye, 2019). Indeed, from the analyses of the demographic and health survey, Haile, Biadgilign and Azage (2015) showed that children from poorer households were less likely to receive VAS. This is unfortunate, because the poor and the most remote are also those who have the lowest composite coverage index, reflecting low coverage of essential reproductive, maternal, neonatal and child health interventions (Baye, Laillou, & Chitweke, 2020). Besides, the implementation of VAS is typically linked with immunizations end at 18 months (last DTP booster) (World Health Organization, 2013), hence limiting opportunities for VAS after that age. As shown in our analysis, albendazole supplementation is facing similar challenges due to this limited contact opportunities after 24 months.

The estimation of the effect size of VAS-related reductions in all-cause mortality led to disparate estimates of 12% and 24% (Mason, Greiner, Shrimpton, Sanders, & Yukich, 2015; Mayo-Wilson, Imdad, Herzer, Yakoob, & Bhutta, 2011; Raiten et al., 2020). This could partly be attributed to the sensitivity of the effects of VAS to the timing and VAS dose, sex of the child, vaccination, maternal vitamin A status and most importantly the rate of infectious diseases (i.e. measles and diarrhoea). The changing global health landscape characterized by reductions in measles and diarrheal infections, along with the scale-up of alternative vitamin A interventions (e.g. fortification) stimulated debate over whether it was time or not to consider the scale-back of VAS programmes. However, such decisions are best made with due considerations of the national/subnational and local context, given the stark geographical inequalities in child mortality (Hay, 2019).

Studying the local variation in childhood diarrhoeal morbidity and mortality in Africa, Reiner et al. (2018) reported that the burden of diarrheal incidence is concentrated within parts of Ethiopia, with the Southern Nations, Nationalities, and Peoples' region (SNNPR), Oromia and Amhara contributing a significant share to the burden of severe cases of diarrhoea in Africa. Immunization coverage in Ethiopia, including measles, is also significantly lower (<60%) than the global target (Tamirat & Sisay, 2019). This context supports our lives saved model that attributed a significant reduction in child mortality to the 15 years of VAS implementation. The model also highlights the additional child deaths that could have been averted with increased coverage of VAS. Provided that a significant proportion of child mortality in Ethiopia is in the first year (Ethiopian Public Health Institute & Inner City Fund, 2016) and vitamin A deficiency is high among pregnant women (Harika et al., 2017), assessing the potential impact of vitamin A supplementation at an earlier stage of infancy could be possible. However, keeping in mind the inconsistent findings and the possible safety concerns raised from studies conducted in different contexts in Africa and Asia (Haider & Bhutta, 2015; West et al., 2019), further studies would be required.

The following limitations should be considered when interpreting our findings. We have used different data sources to show the trend in VAS coverage, partly because the way the data were captured evolved with the change in delivery modality. We, however, tried to validate the VAS coverage by using the coverage of albendazole and also by comparing coverage estimates from DHS and DHIS conducted in the same years. The mortality reductions associated with VAS came from the literature and showed high variability (12–24%). Despite the wide ranging difference between the mortality reduction estimates (12% vs. 24%), our conclusion remained the same. Future studies should, however, estimate the child mortality reductions associated with VAS, both at the national and subnational levels, to more accurately reflect the contribution of this programme under varying contexts.

5 | CONCLUSION

The present study estimated that the VAS programme in Ethiopia averted more than 167,000 child deaths over the last 15 years. Increasing the coverage and reducing inequities in access to vitamin A supplementation is critical. Alternative and complementary interventions like vitamin A fortification and dietary diversification should also be set-up to increase daily vitamin A intakes. This should be accompanied by a close monitoring of the benefits and safety of VAS programmes in areas where multiple vitamin A interventions overlap.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The opinions and statements in this article are those of the authors and may not reflect official policies or opinions of the organizations they belong to.

CONTRIBUTIONS

AL, KB and SC did the study design, data analysis and interpretation. AL and KB drafted the manuscript. AL, KB, SC and MZ reviewed the manuscript. All authors approved the final manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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