

Factors Influencing Dietary Diversity in Infants in India: Study Undertaken in Two Districts

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Abstract—Adequate feeding practices in early life have a lasting impact on child nutrition and development. This paper examines the dietary diversity and its associated factors among children aged 6-12 months, in the age that they transition from breastfeeding to complementary feeding, in two districts in India: Udupi (Karnataka) and Sambalpur (Odisha). In 2019, a citizen-led survey, that can be scaled up further very rapidly and cost-effectively, was conducted covering 976 mothers of children below 1 year of age by 90 trained local volunteers. The survey tool uses the Knowledge, Access and Practices Framework and was developed, tested and refined over 4 years through diverse pilots in various locations in India. In the sample, only 12% children aged 6-12 months met the WHO's minimum dietary diversity requirement. A linear probability regression model was used to assess significant factors for an adequate diversified diet intake in infants. Maternal education, child's age and meal frequency were found to be significantly associated with dietary diversity. Other factors such as household wealth, gender of child, birth order and homegrown gardens did not present a strong association. Integrated interventions targeted at mothers and children that include nutrition education components into mothers' education are more likely to be effective in improving infant dietary diversity.

Index Terms—child nutrition, citizen-led survey, dietary diversity, India

I. INTRODUCTION

Globally, 150.8 million children under five years of age are stunted and 50.5 million are wasted, while 38.3 million are overweight [1]. Combating malnutrition in all its forms is one of the greatest global health challenges.

India continues to struggle with mainly two forms of malnutrition: undernutrition and micronutrients deficiencies (particularly anaemia, which affects more than 50% of children [2]). Recent data from the Comprehensive National Nutrition Survey in India [3] indicates improvements in under-5 mortality rate and prevalence of stunting among children. However, the Global Hunger Index Report 2019 shows wasting rate has risen from 16.5% in 2008-2012 to 20.8% in 2014-2018 [4]. In its global rank, the report places India in the 102nd position out of 117 countries, a significant fall from the 95th position in 2010. Home to almost one third of all

stunted children in the world, the malnutrition crisis in India is an urgent situation in dire need of attention.

Addressing malnutrition should begin in the early years, particularly during the first 1000 days, starting from the time of conception. While most efforts are focused on eradicating hunger, that is, ensuring children have the right quantity of calories intake, more attention should be placed on food quality. This is the time-period where micronutrient deficiencies set in, also termed as "hidden hunger". Feeding practice at this early age not only affects the nutritional status of the young child but has long term effects on their development and overall health [5]-[7].

One way of assessing the nutritional status of children in their early years is by examining their dietary diversity [8]. A diet that is diverse in food groups not only helps to meet the caloric requirement but also contributes to the intake of necessary micronutrients for adequate growth and development [9]. Moreover, measuring dietary diversity can also help in monitoring the impact of interventions focused on food quantity and quality [10].

This paper uses the World Health Organization's (WHO) definition of 'dietary diversity' and 'minimum acceptable diet' [11]. A child is considered to meet the minimum dietary diversity if she/he is receiving food from at least 4 food groups (out of a total of 7 food groups), using a 24-hour diet recall method. Additionally, to have a minimum acceptable diet, the child needs to meet both the dietary diversity requirement and the minimum meal frequency during the previous 24 hours.

According to data from the National Family Health Survey 2015-16 (NFHS-4) [2], approximately 22 percent of children aged 6-23 months across India have minimum dietary diversity; 36 percent meet the minimum meal frequency; and only 9.6 percent consume a minimum acceptable diet.

Several researches have also found that diversified dietary intake among children in low and middle-income countries is positively associated with individual and socioeconomic factors. Maternal education, household wealth, household monthly income, homegrown gardens, family size and mothers' exposure to media are among factors influencing early child dietary diversity in different developing countries [10], [12]-[15].

This paper is based on data collected in 2019 in two rural districts in India. The survey was conducted by citizen-volunteers and used a survey tool which was

developed, piloted and refined over 4 years. The present paper focuses on nutritional outcomes of children aged 6-12 months, a crucial age in which they are expected to transition from exclusive breastfeeding to complementary feeding and start having a healthy and diversified diet necessary for their full development.

II. METHODOLOGY

Data used in the analysis of this study comes from the ASER Health survey conducted in Udupi district and Sambalpur district, which are located in the states of Karnataka and Odisha respectively.

ASER Health is a household survey, conducted by citizens, using an approach similar to the Annual Status of Education Report (ASER), a survey regularly carried out by ASER Centre and Pratham Education Foundation. The ASER surveys first began in 2005 in response to the absence of nationally representative data capturing learning outcomes in India. Today, ASER continues to be referenced as the only reliable and frequent source of information for assessing learning levels amongst children in India. The ASER survey is simple, rapid and citizen-led, making it a model which is easy to administer and highly scalable. For this reason, the 'ASER approach' had been replicated in several other developing countries in South Asia, Africa and Latin America, creating a network of 14 nations conducting similar citizen-led learning assessments¹.

The ASER Health survey adopts this 'ASER approach'. With a simple, robust and scalable model, it is designed to periodically assess health indicators of interest. In the first module of ASER Health, children aged 0-1 year and their mothers were surveyed, to assess their feeding and health practices during pregnancy and the child's first year of life. A subsequent pilot was done with additional questions in the tool to explore extending this survey to target children 0-2 years and their mothers, to cover the first 1000 days of a child's life, considered to be the most important from a health and nutrition perspective. However, in this paper, we have only used the results from the two district-level surveys, done for 0-1-year-old children and their mothers.

The process of finalization of the survey framework and tool included literature review, consultations with external experts and extensive piloting in several areas in the country, in which survey tool, sampling strategy and the operational model were iteratively tested and refined. Throughout this process, nearly 5000 children of 0-1 year of age and their mothers were surveyed in India.

The district-level surveys this paper analyzes were conducted in February and March 2019 with the finalized methodology, which follows all the key elements of an ASER approach, as further explained below.

A. ASER Survey Approach

1) Sampling strategy

To ensure that data is representative at the district level, ASER Health uses a two-stage sampling strategy. In the first stage, for each surveyed district, 60 villages are randomly selected from the Census 2011 village directory, the latest census available in India, using the probability proportional to size (PPS) sampling method. In the second stage, for each village selected previously, 12 households with infants in the age group '0-12 months' were sampled, using a modified "5th household rule"².

The two district-level surveys covered a total of 976 mothers of children below 1 year of age and was implemented by 90 trained volunteers, selected locally from the districts. The current paper on diet diversity focuses on children aged 6-12 months to explore to what extent they meet the minimum dietary diversity (that is, consume at least four of the seven food groups based on a 24-hour diet recall method) given their household wealth, mother's education, birth order, child's gender, number of feeds and whether they are being breastfed, among other variables.

2) Survey tool

The survey tool was designed to be simple so it can be administered by local volunteers, yet robust, in order to present actionable indicators to inform decision-making at various levels, including the household, community and government. Using a knowledge, access and practices framework, the survey tool covers eight key areas of Infant and Young Child Feeding (IYCF) and Health. These areas are: food habits of the mother and the child; child's supplementary feeding; feeding during pregnancy; IFA consumption; quality of drinking water; understanding about diarrhea; and use of health services.

The survey tool captures current levels of knowledge, access and practices as well as the reasons behind these at the household level. This can help informing targeted improvements which could be achieved in a relatively short period of time.

3) Operational model

The ASER operational model is unique: it is carried out entirely by citizen-volunteers who are trained over a few days, and who may not have any prior expertise in surveys. The ASER Health survey emulated this model, wherein citizen-volunteers were locally recruited and trained over a period of three days before they conducted the survey. Monitoring and re-check processes during and after the survey were also carried out by the central and state teams at ASER Centre, ensuring reliable and robust data from the surveys.

¹ The PAL Network (People's Action for Learning Network) was created in 2015. <https://palnetwork.org>.

² The "5th household rule" is the method used in the ASER survey, whereby the selected village is divided into four sections, and the survey team begins the survey from its center, selecting every 5th household found on the left. For the ASER survey, 5 households are sampled in each section of the village (totaling 20 households per village), including those that do not have children in the targeted age of 3-16 years. For ASER Health, this approach was modified to sample 12 households, but all of which with infants aged 0-12 months. For example, if the 5th household on the left does not have a child in this age group, the neighbouring house is approached, until the team finds one with the target child of 0-12 months.

B. Analysis

The analysis provides evidence of low dietary diversity in the surveyed districts. It further explores the factors that may be significantly associated with consuming a diverse diet, using the linear probability model of regression, wherein the dependent variable is binary: it takes value “1” for child aged 6-12 months who have met the minimum diet diversity or takes value “0” if the child does not meet the criterion.

The model accounts for factors that are found to impact dietary diversity in other studies, like parent’s education, household wealth (measured by the proxy - house type, wherein *pucca* house is indicative of a wealthier household as compared to a *kuccha* house³), parents’ age, household size, the age and sex of the concerned child, the number of feeds they have taken in the last 24 hours and state fixed effects.

Table I below depicts the demographics of the surveyed sample.

TABLE I. SAMPLE DISTRIBUTION

Demographics	All	Udupi	Sambalpur
Age of child			
6-8 months	49.7	50.2	48.6
9-12 months	50.3	49.8	51.5
Sex of child			
Male	45.1	45.7	43.9
Female	54.9	54.3	56.1
Breastfed			
Mother's age (mean, in years)	27.4	28.7	24.8
Father's age (mean, in years)	33.3	34.9	30.4
Mother's education			
No schooling	3.9	1.7	8
Less than primary level	2.3	2	2.9
Completed primary	20.7	20	21.9
Completed upper-primary	16.6	11	27.2
Completed secondary or beyond	56.6	65.3	39.9
Father's education			
No schooling	3.1	1.6	6
Less than primary level	5.4	5.2	5.8
Completed primary	24.3	25.4	21.9
Completed upper-primary	16	8.8	30.1
Completed secondary or beyond	51.3	59	36.2
Type of house			
<i>Kuccha</i>	84	97	59.4
<i>Pucca</i>	16	3	40.6
Asset ownership			
Households owning agricultural land	41	28.1	64.8
Households owning livestock	48.9	46.9	52.9
Households owning motorized 2-wheeler	59.4	69.2	41.1

³ *Pucca* houses are more solid and costly structures, typically made of concrete or clay tiles; while *kuccha* houses are simpler houses, built in a traditional method with mud and organic materials.

Households owning motorized 4-wheeler	20.2	28.8	3.2
Households with Electricity	98	97.7	98.6
Households with Mobile phones	98.1	99.2	96
Households with Television	88.5	95.5	75.2
Total number of children	494	324	170

Note: All numbers reported are in percentage unless otherwise specified.

III. RESULTS

A. Dietary Diversity

The proportion of children meeting the minimum dietary diversity is very low. Fig. 1 below depicts the number of food groups consumed by children aged 6-12 months across the two districts. It shows that on average only 12% of children from both districts (12% in Udupi and 13% in Sambalpur) were found to meet the WHO prescribed dietary diversity. Most children consume utmost 2-3 food groups.

The data also indicates that almost all children (99%) in this age group of 6-12 months continue to be breastfed, which is in line with the recommendation of WHO [16], [17]. However, in Sambalpur, almost half of them (49%) are still being exclusively breastfed and thus not receiving any complementary food. In Udupi, this number is much lower (only 5%).

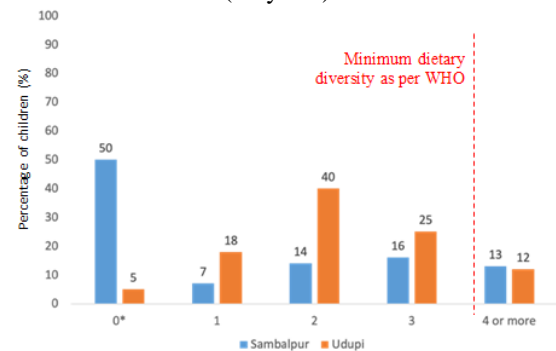


Figure 1. Sample distribution of number of food groups consumed.

* Children consuming 0 food group include those being exclusively breastfed or exclusively fed packaged foods (such as formula milk or food, snacks, etc.).

B. Most Consumed Food Groups

Further unpacking the results shows that the most prominently consumed food group in both, Sambalpur and Udupi, was cereals/grains/tubers (Fig. 2).

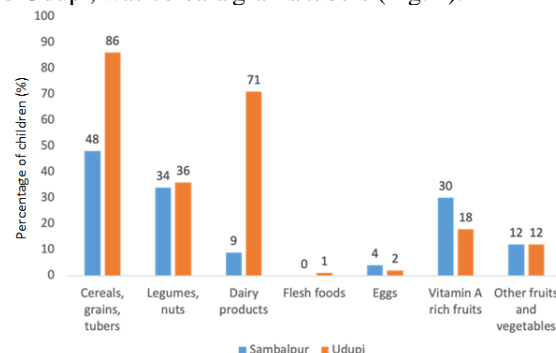


Figure 2. Sample distribution of food groups consumed.

The most consumed food groups in Udupi are cereals/grains/tubers, dairy products and legumes/nuts. For Sambalpur, the most consumed food groups are cereals/grains/tubers, legumes/nuts and, vitamin A-rich fruit. The consumption of flesh foods and eggs is extremely low across both districts and age groups.

C. Access to Services: Anganwadi Centres

The survey also collected data about access to services, such as those provided by the Anganwadi Centres (AWCs). The AWCs are childcare centres, under the Integrated Child Development Scheme (ICDS) run by the Ministry of Women and Child Development, Government of India, with each state government administering this mandate within their respective states. The AWCs provide supplementary nutrition, pre-school education, nutrition and health education and referral services. For nutritional purposes, the scheme provides for 500 kilocalories (with 12-15 grams of protein) every day to every child below 6 years of age.

As Fig. 3 shows, only a low proportion of mothers feed their child food from AWCs: around 65% of children were not fed food from these centres in the previous two weeks. For 39% of them, this was due to the mother's perception that the child was too young for it (Table II).

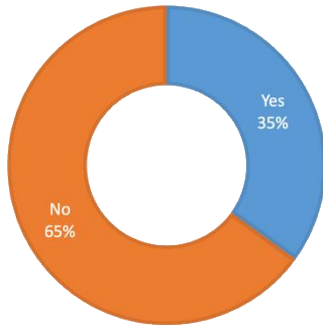


Figure 3. Children fed food from AWC in the last 2 weeks.

TABLE II. REASONS FOR NOT FEEDING FOOD FROM AWC

Reason why child was not fed food from Anganwadi centres in the last 2 weeks	
Child is too young	39.3
Family members asked to do so	23.2
Did not get from AWC	14.8
Did not like the taste	10.7
AWC is too far	7
Did not know about the facility	6.7
No need for AWC food	5.4
Poor hygiene	2.7
Lack of time	1.7
No specific reason/ other reasons	29.6

Note: All numbers reported are in percentages. Respondents could select multiple answers; thus, the total percentage exceeds 100%.

D. Associated Factors to Dietary Diversity

In order to understand the association of factors like mother's education and household wealth on consuming a diverse diet, a multivariate regression analysis was conducted. In the analysis, we focus on two sets of regression. In the first model, the threshold of the dependent variable is set for consuming at least four food groups, in accordance with WHO guidelines. In the second regression, we lower the threshold to the consumption of at least three food groups to check if the association of above-mentioned factors continues to hold.

TABLE III. REGRESSION RESULTS

Outcome variable: Meets prescribed minimum diet diversity	Model 1: At least 4 food groups consumed	Model 2: At least 3 food groups consumed
Number of feeds	0.0357*** (0.008)	0.0502*** (0.012)
Mother's education		
Less than primary level	0.0462 (0.090)	0.0993 (0.241)
Completed primary	0.2083** (0.096)	0.1078 (0.145)
Completed upper-primary	0.1764* (0.090)	0.3346** (0.148)
Completed secondary or beyond	0.2301** (0.091)	0.2009 (0.142)
Father's education		
Less than primary level	-0.3407 (0.207)	-0.0969 (0.249)
Completed primary	-0.4015** (0.202)	-0.2674 (0.219)
Completed upper-primary	-0.2797 (0.205)	-0.2237 (0.216)
Completed secondary or beyond	-0.3171 (0.203)	-0.2178 (0.217)
Total number of household members	0.0008 (0.006)	0.0132 (0.009)
Sex of the child	-0.0007 (0.033)	0.0079 (0.051)
Child age: 9-12 months	0.1352*** (0.033)	0.1851*** (0.051)
Household has home gardening	-0.0480 (0.035)	-0.0650 (0.053)
Household type (Kuchha house is reference)	-0.0498 (0.055)	-0.0300 (0.076)
Child is breastfed	0.5057*** (0.151)	0.2893* (0.150)
Age of mother	0.0158** (0.007)	0.0081 (0.009)
Age of father	-0.0065 (0.005)	-0.0083 (0.007)
Udupi (district control)	-0.1656*** (0.054)	-0.0690 (0.074)
Constant	-0.5149* (0.283)	-0.1260 (0.342)
R-squared	0.1948	0.1451
Observations	418	418

Note: Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Refer to the appendix for the entire variables list with description

Table III presents the regression results. It shows that, among the variables examined, number of feeds a day, child's age and mother's education were consistently found to have statistically significant association with dietary diversity.

In our sampled children and their mothers, we observed that, with an increase in the number of feeds a day, the probability of meeting the prescribed diet diversity increases by 3.6 percentage points and the association is highly significant. With regard to child's age, those who are 9-12 months old are more likely by 13.5 percentage points to consume at least four groups compared to those who are 6-8 months old. With regard to mother's education, children of mothers who have completed at least primary level of schooling have a higher chance of meeting the minimum diet diversity by 20.8 percentage points. On reducing the threshold to consuming at least three food groups, number of feeds, age of child and mother's education continue to have a positive and significant association.

Other factors, such as mother's or father's age, present a weak association to the variable of interest or no significant association, depending on the threshold considered. Factors like father's education status, home gardening and sex of the child seem to have no significant correlation on meeting the minimum diet diversity.

IV. DISCUSSION

The transition from exclusively breastfeeding to initiation of home-based food to the child, termed as complementary feeding, is a vulnerable phase, as this is the time when chances of malnutrition increase [18]. It is crucial to introduce an adequate diet – in both quality and quantity of food - in the initial years of life.

However, results from the surveys done in the two districts indicate that complementary feeding is not initiated at the appropriate age: 5% and 49% of children in Udupi and Sambalpur respectively are exclusively breastfed even after the age of six months. In some cases, children were fed only formula milk at an age where they should be fed complementary foods along with it.

Not only is complementary feeding not starting in a timely manner, but it is also not satisfactory in term of its diversity. Analyzing the food groups consumed by infants, our findings from these two districts show that a very low proportion of children (only 12%), in the age group of 6-12 months meet the required diet diversity. This is lower than the national average rate presented by the National Family and Health Surveys-4 (2015-16), which pointed to a proportion of 22% of children aged 6-23 months meeting the dietary diversity threshold across India [2], [19]. This difference may be due to a broader age group targeted in the NFHS.

The most consumed food group is cereals, similar to the findings of other studies [20]. This is not surprising, given that, as a staple food in India, cereal is widely consumed and easily accepted [21], as well as relatively inexpensive.

Looking into the reasons behind feeding practices, our findings indicate that mothers are mostly unaware of the recommended practice regarding initiation of solid and semi-solid feeds to the child. Most children were not being fed food offered by Anganwadi Centres, the main reason for it being that mothers thought their children were too young for it - despite their children being already at the age for getting complementary feeding according to national and global guidelines [16], [17], [22].

The association between dietary diversity and child's age – with children aged 6-8 months old less likely to consume at least four groups than those aged 9-12 months – may also point to this lack of understanding about the appropriate age to introduce complementary feeding.

The fact that mothers' education was among the main factors associated with dietary diversity also corroborates this hypothesis. Mothers who have completed at least primary school are more likely to meet the minimum dietary diversity for their children as compared with those mothers who have no formal education. This is consistent with similar studies conducted elsewhere [12], [23]-[28]. Mothers with more formal education may be more knowledgeable about infant feeding practices.

It is also important to note that the study has not found a significant association with household wealth, estimated by a proxy (type of house). Even when we estimated household wealth by a composite index with a set of indicators (type of house and ownership of assets such as land, livestock, motor vehicles, television and mobile phones), the association with dietary diversity was not statistically significant. This result is different from most studies in India and other developing countries, which did find a positive correlation among these variables [12], [28]-[31]. More research would be needed in other rural areas of India in order to assess if indeed wealth does not matter much for the dietary diversity of young children.

It is also noteworthy that the two districts surveyed have very different socioeconomic levels. Udupi's social and economic indicators are substantially higher than Sambalpur's: literacy rates are 86% and 76% respectively and per capita income is four times higher in Udupi (INR 202,618 compared to INR 55,656) [32], [33]. The data analysis, however, did not show a consistent association between districts and dietary diversity, meaning that children from a certain district is not more likely to consume feeds from at least four food groups than children from the other district, controlling for other factors. Notwithstanding, differences were found in breastfeeding practices and on food groups mostly consumed.

Another variable that we surprisingly found not to be a good predictor of dietary diversity is home-gardening. For our targeted population, even if the households are growing fruits and vegetables themselves, they are not necessarily using these produces to feed their child. Given that age is significantly associated with dietary diversity, the fact that this study focuses on children aged 6-12 months may be an explanatory factor to understand why a correlation with home-gardening was not found,

which is different from others studies (targeting children aged 6-23 months) [13], [34], [35].

It can be inferred from the results of this study that there is possibly a lack of awareness and information amongst mothers and caregivers about proper feeding practices for children less than one year old. To address this issue, it becomes pertinent that proper nutrition education is done within the communities, reaching out to the mothers and caregivers to provide accurate information about best feeding practices for children, particularly in their first 1000 days [10], [36]. Designing and implementing nutrition education interventions with sustained positive behavioral impact among communities is a major requirement to address the nutritional needs of children in their very early years. To help overcome this challenge, research studies have pointed to successful experiments in influencing infant and young children feeding practices for children in their early years [37].

To effectively bridge the gap between knowledge and practice, it should also be ensured that people have the means and resources to access a diverse food basket. To this end, it is important to couple nutrition education components with programs aimed at increasing access to nutritious and diverse food.

The results of this study also point to the centrality of mothers' education for infant nutrition. This provides a strong case for strengthening investments in women's education. While educating women is an important end in itself, its strong association with children's nutrition points at other inter-generational benefits as well.

Therefore, integrated policies and programs targeted at mothers and children that combine nutrition education components into mothers' education, better delivery of services (such as more diversified and nutritious food rations in Anganwadis Centres) and other nutrition interventions (such as programs that promote access to healthy food) are likely to be most effective in improving dietary diversity among infants.

Stepping up efforts to provide better nutrition for children in India, with a focus on the first 1000-days window of opportunity, will not only fulfill their right to adequate and nutritious food but also aid the country to reap the benefits of its demographic dividend, raising healthy and productive citizens, who can fully attain their development potential.

APPENDIX A DEFINITION OF VARIABLES

Number of feeds is the sum of number of milk feeds (other than mother's milk) and the number of feeds other than milk (complementary feeding). It ranges from 0 to 10, in a day (recall period is 24 hours).

Mother's education has been categorized into four levels: (i) Less than primary level, (ii) Completed primary, (iii) Completed upper-primary, and (iv) Completed secondary or beyond.

Mother's age is the current age of the mother.

Father's age is the current age of the father.

Father's education has been categorized into four levels: (i) Less than primary level, (ii) Completed primary,

(iii) Completed upper-primary, and (iv) Completed secondary or beyond.

Sex of the child refers to whether the child is male or female. It is represented by a binary variable that takes the value of 0 if female and the value of 1 if male.

Child age refers to the age category the child falls into. It takes the value of 0 if the child is between 6 to 8 months of age and the value of 1 if the child is between 9 to 12 months of age.

Home gardening refers to whether the household grows some food items in the house itself. It takes the value of 1 if they do and value of 0 otherwise.

Child is breastfed refers to whether the child is currently consuming mother's milk. It takes the value of 1 if the child is currently consuming mother's milk and 0 otherwise.

District control refers to whether the district is Udupi or Sambalpur. It takes the value of 1 if it is Udupi and 0 for Sambalpur.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors were part of the ASER Health project.

Dr. Wilima Wadhwa and Prerna Makkar guided and supervised the entire project. Karishma Vats and Pankhuri Mishra oversaw the development and deployment of the survey tool. Steffi Elizabeth Thomas and Maitreyee Krishna organised and analysed the data. Candice S. Vianna and Ayushi Singh synthesised every author's inputs and wrote the paper.

All authors have approved the final version.

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