

Evaluation of Social Marketing Intervention for Diarrhoea

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ABSTRACT

Diarrhoea is one of the leading causes of childhood mortality in India. This study analysed the diarrhoea management practices of the caregiver according to the framework of protect, prevent and treat intervention promulgated by the Integrated Action Plan for the Prevention and Control of Pneumonia and Diarrhoea using Bayesian network analysis. The data is collected for preventive and protective measures as well as treatment preferred by the caregiver from the intervention districts of Gaya and Purnea of Bihar state using multi-stage cluster sampling. The Bayesian network model is developed presenting the conditional dependency of campaign and awareness on the adoption of the practice of preventive and protective measures as well as treatment. Structural validation test supported the model, after parameter estimation, the joint probability for the prevention, protection and treat conditional to campaign media and awareness of various causes of diarrhoea is estimated. The inference supported the use of handwashing, cleanliness, sanitation, safe drinking water, breastfeeding and vitamin as the common preventive and protective measures, and ORS to treat the child.

Keywords: Social Marketing, Bayesian Network, Diarrhoea, Mortality, Morbidity

INTRODUCTION

A universal intervention programme, Global Action Plan for the Prevention and Control of Pneumonia and Diarrhoea (GAPPD) had been initiated in 2013 by World Health Organisation (WHO) and United Nations International Children's Emergency Fund (UNICEF) for the control of acute respiratory infection, and diarrhoeal disease, as well as to expand the programme on immunisation (Kassegne et al., 2011; Kaur & Singh, 2023). GAPPD propose an integrated framework of interventions to protect, prevent and treat children's health against the disease (WHO, UNICEF) (Evans et al., 2014). India sought the help of this universal programme to achieve the United Nation's Sustainable Development Goal target of reducing under-five mortality to 25 per 1000 live births by 2030 (Business Standard, 2019).

GAPPD on the basis of an integrated framework of intervention with ten indicators set a target score for developing countries of 86% reduction of these diseases for each country. India one of the signatories to the plan performed better by scoring 65% for pneumonia against

target score of 84%, but able to achieve only 39% against the target of 82% (Business Standard, 2019). This underperformance in controlling the diarrhoeal disease is a serious concern related to public health.

Government of India in the line with GAPPD and to achieve 2030 goal, launched Integrated Action Plan for Pneumonia and Diarrhoea (IAPPD) in its few states with high child mortality rate due to Diarrhoeal disease. The action plan of IAPPD is to assess the gaps in the health system and formulate the plan to fulfil these gaps to expedite the process of achieving the 2030 target of ending the preventable child deaths (Akbar et al., 2021). IAPPD follows the GAPPD integrated framework, a social marketing programme of ten interventions to protect, prevent and treat diarrhoeal disease. The implementation of these interventions is needed to be continuously monitored, that needs a better and efficient evaluation mechanism to prevent social marketing to fail, which would also guide for further planning and better organisation of health facilities to the people (Langford & Panter-Brick, 2013; Akbar et al., 2023).

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Social marketing is the use of marketing principles and techniques to influence a target audience and to bring about a change in the behaviour for the benefit of individuals or society (Kotler, 2022). The social marketing efforts are focused towards the welfare of the community by causing behavioural change through applying marketing techniques (Kim et al., 2020).

The Bayesian network attracted much attention in recent years particularly in the field of health (Borsboom, 2017). It proved to be a strong tool for establishing causality (Pearl, 2009). The Bayesian network is also known as a causal network it depicts a verifiable causal structure of the relationship between random variables (Pearl, 1986), hence it is preferred for analysis as it will prove to be useful in verifying the dependency of intervention activities on disease control.

The specific aim of this research is to model IAPPD social marketing intervention into the bayesian structure and evaluate the effectiveness of the programme by verifying the usage of intervention by the people. Our research is based on the primary data collected from the household of sufferers of diarrhoea from the intervention area. The results of the study will enable us to identify the intervention delivery and acceptance. The model and tool developed will enable the project manager to review their implementation and detect deviation that will ultimately contribute to the maximum impact of interventions in controlling the disease.

LITERATURE REVIEW

Social Marketing

The emergence of social marketing is dated back in 1952 when G.D. Wiebe thought of such techniques that could successfully change the behaviour of individuals and community. He propagated that expertise from traditional marketing can be utilised to address the problem faced by the society (Wiebe, 1952), consequently, the use of social marketing is widely recognised and used as an effective tool to influence the 'health behaviour' of the individuals as well as to address public health-related problems. It has been very instrumental in changing the person's beliefs and actions regarding their health and well-being (Kotler & Zaltman, 1971; Kotler, 2022).

Philip Kotler and Gerald Zaltman (1971) defined social marketing as "social marketing is the design, implementation and control of programs calculated to influence the acceptability of social idea and involving consideration of product planning, pricing, communication, distribution and marketing research."

According to Ragun and Karim (1991) social marketing involves; (a) "changing attitude, beliefs and behaviours of individuals or organisations for social benefit and promoting quality of life" (Christie & Venter De Villiers, 2023) and (b) "the social change and sustainable development is the primary purpose of the campaign (Delvaux & Van den Broeck, 2023)." Kotler and Roberto (1989) believed social marketing as a social change campaign, and defines as "an organised effort conducted by one group (the change agent), which intends to persuade others (the target adopters) to accept, modify or abandon certain ideas, attitudes, practices and behaviours (Kotler, 2022)." Keeping in mind all the above explanation and definition, Kotler (2022) proposed his definition of social marketing as the adaptation of commercial marketing technologies to programs designed to influence the voluntary behaviour of target audiences to improve personal welfare and that of the society of which they are the part (Andreasen, 1994).

Social Marketing Intervention

The objective of the social marketing intervention is individual, community or structural changes (Abuhussein & Magatef, 2023). Andreasen (2002) proposed that social marketing intervention influence social change at three societal levels. First, at the individual level, second at the community and third at the law and framing public policies.

At the first level, it is believed that for some social problem individuals are responsible which can be reduced or eliminated by focusing on individual change such as drunk driving, smoking, etc. Social workers with a psychologist are assigned this class of intervention to educate individuals (Kaur & Singh, 2023).

At the second level, the focus of the intervention is the whole community. The social problem faced by the community at large requires the motivation of the community to play a major role in addressing. It requires

designing, implementing and evaluating appropriate social marketing intervention programme (Mueller, 2023). Social marketers favour mostly community-based intervention because according to them the community norms and values with interpersonal influence supported by community institutions will ensure the success of the programme, which can't be achieved by the individual-based intervention (Gray-Felder & Deane, 1999). Community mobilisers and social workers with anthropologist and sociologist are assigned this intervention (Akbar et al., 2021; Nnindini & Dankwah, 2023).

At the third level, the social problems are addressed by framing laws, imposing accountability for institutions and public policies, when social change at individual and communities level fails. This intervention use courts and law-making to end social evils (Andreasen, 2002; Evans et al., 2014).

Andreasen (2002) proposed that the choice of the intervention depends upon the social problems and issues involved (Kotler, 2022). The social issues such as health care, social welfare and environment are mostly addressed; each of them had its own requirement of intervention specialties. The "health care" has achieved a wider acceptance and is most benefitted by this field (Blair, 1995; Hastings & Haywood, 1991; Lefebvre & Flora, 1988; Rothschild, 1999).

Social marketing intervention is useful in gaining cooperation from the stakeholders who are needed to make intervention successful such as media, policymaker, funding agencies, etc. (Hastings & Haywood, 1991).

Evaluation of Intervention

According to Andreasen (2002), the choice of social marketing intervention depends upon two criteria effectiveness and appropriateness (Nosi et al., 2021). He noted that effectiveness of social marketing intervention is based on whether there is the actual behavioural outcome in terms of increase in awareness or attitude change, furthermore successful in persuading the people and community to improve their welfare by abstaining themselves from the behaviour that is detrimental to their health (Hastings & Haywood, 1991; Kaur & Singh, 2023). The appropriateness is in the context the social marketing

is used. The choice of intervention for the segment targeted must be appropriately designed with offerings that should match the needs of the population targeted further result in the fast and better pick of the intended behaviour (Akbar et al., 2023). The interventions of social marketing generally are intended to make the people who are targeted to take on the behaviour which is promoted (Akbar et al., 2021).

Integrated Action Plan for Pneumonia and Diarrhoea

A GAPPD was developed in 2013, by WHO and UNICEF globally aimed at reducing child death to less than 1 in 1000 due to Diarrhoea by 2025 (Delvaux & Van den Broeck, 2023). As an adaptation of GAPPD Government of India under National Health Mission in September 2014 launched the IAPPD in four states of India which contribute to 58% of child deaths - Bihar, Uttar Pradesh, Madhya Pradesh and Rajasthan (Kaur & Singh, 2023). The aim of IAPPD is to address the gaps in the health system and formulate the plan to fulfil these gaps to expedite the process of achieving the target of ending the preventable child deaths (Yewale, 2014).

IAPPD follows an integrated intervention approach similar to GAPPD Ten key interventions to Prevent, Protect and Treat Diarrhoea. The Protect approach includes (a) exclusive breastfeeding, for six months, (b) adequate complementary feeding and (c) vitamin A supplementation. The Prevent approach includes (a) handwashing with soap, (b) safe drinking water and sanitation and (c) Vaccines: rotavirus, measles. The Treat approach focuses on (a) Improved care-seeking and referrals, (b) case management at the health facility and community level (c) continued feeding (including breastfeeding) (d) Supplies: low osmolarity ORS, zinc, antibiotics and oxygen (Yewale, 2014).

IAPPD integrated approach with National Health Mission also focuses on the framework for strengthening coordination of existing interventions, coordination with agencies, and between programmes and partners for the strengthening of social and behaviour change. Major activities include orientation and capacity building of key stakeholders, mobilisation of community-level institutions, advocacy with private providers, knowledge management for better planning.

IAPPD, wish to achieve its objective by strengthening community and provide a facility through its various levels of activities. Among facility-level activities, establishment of Oral Rehydration Therapy corner in Primary Health Centre, Community Health Centre and District Hospital is one of the initiatives to mobilise community regarding management of diarrhoea cases. Oral Rehydration Therapy corner includes the establishment of ORS and Zinc corners for treatment and counselling of diarrhoea near hospital OPD area. The health worker is designated to manage Oral Rehydration Therapy corner and counsel mother regarding the preparation of ORS solution and importance of activities like exclusive breastfeeding, hand-washing techniques moments of hand-washing, the importance of vaccination and many more as per IAPPD framework. Other facility-level activities include capacity building of Angan Wadi workers to train the community based on IAPPD framework approach of prevention, protection, and treatment of diarrhoea. Community-level activities include distribution of ORS to households and counselling by Accredited Social Health Activist, promotional activities by Auxillary Nurse Midwifery on hygiene and sanitation along with management of diarrhoea, hand washing demonstration in schools and out-reach sessions.

MATERIAL AND METHODS

Dataset Collection

Variable Definition

Data was collected on the six dimensions for evaluating an intervention, three dimensions were of IAPPD interventions viz. prevent, protect and treat, while the source of information about the Diarrhoea intervention, awareness about the reason of diarrhoea, and the suffering of the child from diarrhoea in days are additional dimensions.

The conditioning factors and its variables are as follows:

- Three variables corresponding to [S] “Source of information” - [S1] Broadcast; [S2] Print; [S3] Word of Mouth.
- Four variables corresponding to [A] “Awareness about the reason for diarrhoea” – [A1] Contaminated water; [A2] Contaminated food; [A3] Stomach infection and [A4] Unhygienic living condition.
- Three variables corresponding for [PRT] “Protect dimension”- [PRT1] Vitamin A supplementation; [PRT2] Adequate complementary feeding; [PRT3] Optimal breastfeeding.
- Four variables corresponding to [PRV] “Prevent dimension” – [PRV1] Washing hand with soap (cleanliness); [PRV2] Using safe drinking water; [PRV3] Vaccines; [PRV4] Practicing improved sanitation (toilet facility).
- Three variables corresponding to [SFR] “Recent suffering of the child from Diarrhoea” – [SFR1] 1–4 days; [SFR2] 5–15 day; [SFR3] More than 15 days.
- Four variables for [T] “Treatment preferred who are ill from diarrhoea” – [T1] ORS- Zinc; [T2] Homemade remedy; [T3] Antibiotic; [T4] Injection.

Variables “Source of information” covers all the major sources used by the Government of India for the dissemination of information about the Diarrhoea interventions viz. ‘Broadcast’ include information disseminated through Television, Radio, F.M Radio, Satellite Television and Cable Television. ‘Print’ includes newspaper, wall painting and pamphlet. ‘Word of mouth’ includes information received by the community members, through relatives, auxiliary nurse and Midwife and ASHA.

“Awareness about the reason for diarrhoea” is about the causes of diarrhoea. “Contaminated water” is the presence of microbes and harmful chemicals in the water. “Contaminated food” is the presence of microorganism and harmful chemicals in cooked food and fruit due to faulty preparation and preservation.

‘Protect’ dimension include activities to provide protection in promoting healthy practices of good nutrition since birth. it includes “Optimal breastfeeding” is the most effective child survival intervention. The antibodies and enzymes found in breast milk boost child immune system. “Complementary feeding” is for the child when breast milk is alone no longer sufficient to meet the nutrimental requirement of an infant; therefore, other foods and liquids are needed. Complementary feeding should be timely, adequate and safe. “Vitamin –A” supplement reduces diarrhoea specific mortality.

“Prevent” dimension include activities to reduce morbidity and mortality. “Vaccination” reduces the disease burden and death caused due to bacteria. “Washing hand with soap” practice contribute to reduction in diarrhoea it is involve washing hand at five key junctures: after going to the toilet, after cleaning up child faeces, before cooking and eating food or feeding the baby (Curtis & Cairncross, 2003; Kaur & Singh, 2023). “Practicing improved sanitation” include proper disposal of child faeces, toilet facility in-home or in the vicinity. It reduces the chance of faecal contamination of water and food contamination through flies. “Using safe drinking water” includes the usage of contamination-free water, which is chemically treated, kept at germ and microbe-free container and storing at a clean place.

“Recent suffering of the child from Diarrhoea” is to know about the latest episode of diarrhoea and suffering period i.e. low (1–4 days); medium (5–15 days); high (more than 15 days).

“Treatment preferred who are ill from diarrhoea” include the usage of “ORS”; “Homemade remedies”; “Antibiotics” including pills and syrups; injection.

SURVEY DESIGN

The survey objective was to gather sufficient information from the caretakers for evaluating the effectiveness of IAPPD interventions. For the purpose mixed method of semi-structured interview with the “schedule” technique was used.

In schedule technique, the formalised set of questions were presented, framed on the GAPPD framework of prevent, protect and treat dimensions.

The schedule was comprised of three parts, first part was about geography including district, block, village, house number, second part comprises of demographic profile of caregiver, name of caregiver, gender, age, education and occupation of caregiver, family size, number of children in house, household income per year, age of younger child in house, relation of caregiver with the younger child in house, duration of recent diarrhoea episode. The third part comprises questions of prevent, protect and treat dimension for reducing pneumonia and diarrhoea morbidity

and mortality. The prevent, protect and treat dimensions include ten key interventions related questions viz. (a) exclusive breastfeeding, for six months; (b) adequate complementary feeding; (c) vitamin A supplementation; (d) handwashing with soap; (e) safe drinking water and sanitation; (f) Vaccines: rotavirus, measles; (g) Improved care-seeking and referrals; (h) case management at the health facility and community level; (i) continued feeding (including breastfeeding) and (j) Supplies: low osmolarity ORS, zinc, antibiotics and oxygen.

The fourth part was miscellaneous questions like the source of water, availability of toilet facility, source of information about diarrhoea, awareness about the reason for diarrhoea, handwashing behaviour and practice. The purpose of this section was to clarify and further explore the response of the third section through a semi-structured interview. The schedule was framed in Hindi “Devnagri lipi” for the ease of understanding by the enumerators, questions in section three were to be responded in dichotomous (Yes and No) form after listening to the direct response and clarifying the same through interview.

Reliability and Validity

For the reliability and validity of the instrument, the systematic errors like respondent’s reaction to survey (shyness, skepticism, language barrier, cultural and traditional barriers) were overcome by developing an acquaintance with them through extending common contacts and meeting at multiple occasions before getting the response and assuring confidentiality of the response. During the survey, the common tendency of the respondents was to get social approval from nearby community member known as social desirability which brings personal bias in the response, was avoided by asking the questions in privacy. Furthermore, to address the common method bias the length and wording of the questions were improved after discussing it with senior professors and linguistic expert of Devnagri. The mock test of questions was conducted with ten colleagues who were qualified to be the mock respondents having a child under age of five, possessing adequate knowledge about the cause and cure of the disease also of intervention initiative for disease prevention and control. The questions content was re-assessed accordingly.

The content and construct related validity was addressed by focusing on the framework suggested by the GAPPD as well as the interventions suggested under prevent, protect and treat dimensions. Schedule questions were framed to know about the people behaviour related to the use of the protective and preventive measure of diarrhoea, and the treatment preferred in case of contracting the disease, the criteria validity was taken care of while asking the question and further in clarificatory questions.

Participants

The study was conducted in the Gaya and Purnea two districts of Bihar. We purposely chose the two districts to survey. Our respondents from target population consist of caregiver (mother, grandmother and elder sister (age more than 16 years), Aunt) from household having a child between 6 and 59 months (Up to five years of age is considered under IAPPD intervention for control of diarrhoea) and resided in the village for last six months. Sample size chosen was 649 (out initial result of 737) was taken which is double of 385 of the value which was determined using the formula

$$n_o = \frac{Z^2 pq}{e^2} \quad (1)$$

Where n_o is the sample size, Z is the abscissa of the normal curve that cutoff an area α at the tails. $(1-\alpha)$ equals the desired confidence level, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and $q = 1-p$. The value of Z is found in the statistical table which contains the area under the normal curve, for example, $Z = 1.96$ for 95% of confidence level (Cochran, 1963).

Multi-stage cluster sampling was used for data collection. One-third of the blocks from Gaya and Purnea were randomly selected, that is, eight blocks from Gaya district & four blocks from Purnea district. Two villages from each block were randomly selected by using lottery method. Respondents were identified from house to house intensively survey by authors. In case of more than one child age between 6 and 60 months were found in the house the survey was conducted for the youngest child. The study was carried out in the year 2017–2019.

Dataset

Survey Results

The survey results in terms of the percentage is given in table:

Table 1: Survey Results

Dimensions	Variables [Percentage]
Source of information [S]	Broadcast [22.3%]; Print [54.8%]; Word of Mouth [54.8%]
Awareness about the reason for diarrhoea [A]	Contaminated water [23%]; Contaminated food [24.3%]; Stomach infection [30.5%]; Unhygienic living condition [22.2%].
Protect dimension [PRT]	Vitamin A supplementation [35.8%]; Adequate complementary feeding [20%]; Optimal breastfeeding [44.2%].
Prevent dimension [PRV]	Washing hand with soap (cleanliness) [26.7%]; Using safe drinking water [34.5%]; Vaccines [20.9%]; Practicing improved sanitation (toilet facility) [17.9%].
Recent suffering of the child from Diarrhoea [SFR]	1–4 days [46.5%]; 5–15 day [34.3%]; More than 15 days [19.3%].
Treatment preferred who are ill from diarrhoea [T]	ORS-Zinc [36.1%]; Homemade remedy [26.9%]; Antibiotic [21.3%]; Injection [15.7%].

Bayesian Network

Bayesian networks are receiving considerable attention from researcher across all the fields. The aim of the development of a Bayesian network is to produce a practical framework for reasoning (Pearl, 2009). According to Darwiche (2010) “Bayesian networks provide a systematic and localised method for structuring probabilistic information about a situation into a coherence whole.”

Pearl (1986) explained the Bayesian network as a causal network of a k -dimensional set of random variables describing a structure of the relationship of interest that are frequently causal. This structure is a pair of (X, G) composed of: a random k -dimensional variable $X = (X_1, \dots, \dots, X_k)$, where the multivariate probability distribution

of X is called global distribution of the data, while the univariate ones associated with each are called local distribution (Matias, Rivas, Martin & Taboda, 2008).

(DAG) G is a directed acyclic graph (Neapolitan, 2004; Nielsen & Jensen, 2009) is modelling the relationship that composed of (V, A) , Where node v is associated with one variable X_i of a set of k vertices (associated with the random variable $X_i, i = 1 \dots k$) and a set of arrows called as directed arcs that connects the nodes representing direct probabilistic dependencies, or between these nodes that represent the causal relationships (Russel & Norvig, 2010).

If π_i is denoted as the set of random variables that are the immediate predecessors of the variable X_i according to the DAG (the parents of X_i), the conditional independence relationship defined by G permit factorisation of the joint distribution (Matias, Rivas, Martin, & Taboda, 2008) via

$$P(x) = p(x_1 \dots x_k) = \prod_{i=1}^k p(x_i | \pi_i) \quad (2)$$

where x_i is a realisation of which facilitates the estimation of the parameters of this distribution from the data. A Bayesian network is fully specified when it's DAG and the right-hand side factors of equation (2) are specified.

The variables in X may be continuous or discrete. In case of continuous variable Bayesian network is modelled as a Gaussian random variable, and in the discrete as a multinomial model.

Construction of Directed Acyclic Graph

The DAG structure is constructed depending upon the computational need. The structure is defined entirely by subject experts based on a priori knowledge in application area or through structural learning (estimation) made from data (Matias, Rivas, Martin & Taboda, 2008).

This structure is in the form of a dependency structure where nodes (v) of the structure are the variable of the interest and arc (a) link the nodes in the structure interpreting formal direct relationship in terms of child and parent (parent node at the tail of the arc and child node at the head of the arc) holding interdependency. These

arc forms a network signifying direct causal influence or relationship (Darwiche, 2010)

Fig. 1 shows a directed acyclic graph (DAG) for the purpose of this study. The causal relationship between the nodes is defined by the theoretical knowledge and after discussing with the subject expert in the area.

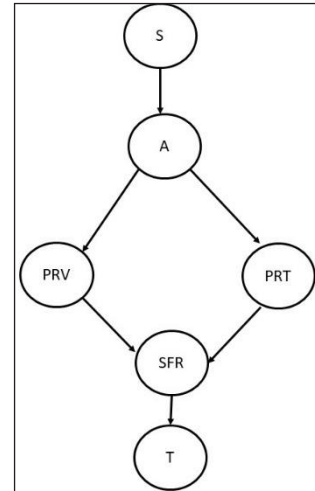


Fig. 1: Conceptual Directed Acyclic Graph

Table 2: Nodes and Probabilistic Representation

Nodes in the graph	"A", "S", "PRT", "T", "SUF", "PRV"	
Bayesian Structure Probabilistic representation:	Pr ([S][A S] [PRT A] [PRV A] [SFR PRT: PRV] [T SFR])	
Arcs in the graph defined by the probabilistic representation	From Node	To Node
	S	A
	A	PRT
	A	PRV
	PRV	SFR
	PRT	SFR
SFR	T	

Once the causal structure is developed it requires data in the form of conditional probability table also known as a parameter for each node connected through an arc as a parent and child. This quantifies the relationship between the variables in the network. The conditional probability table specifies a conditional probability of child given its parent(s), this parameter of the network (*a priori*) is obtained from the population survey (Darwiche, 2010).

RESULTS

Bayesian Network Analysis

In Bayesian network analysis, the model validation and parameter estimation are done as a two-step process and then the inference is drawn from the Bayesian network (Scutari & Denis, 2015).

- Structural validation.
- Parameter estimation from local distribution by the structure of the DAG estimated in the previous step.
- Belief updating.

Structural Validation

The structural validation is to investigate the structure of the DAG built on the basis of theoretical knowledge or

suggested by the expert. It is to validate the inclusion of the arc in the graph i.e. to identify which nodes are directly related or not according to the purpose of the study.

For structural validation (Scutari & Denis, 2015) it is suggested to use a conditional independence test for estimating the requirement of each arc in the DAG structure. The conditional independence test is performed under the null hypothesis of “probabilistic independence represented by the arc”. The rejection of probability independence of the arc supports the probabilistic dependence of the node by data and arc is considered to be important for the structure.

The ‘arc.strength’ function of bnlearn package of R is used (Scutari & Denis, 2015) to conduct conditionally independence test with criterion. The conditional independence test verified the causal relationship existing in the network.

Table 3: Output Table for Conditional Independence Test of Arcs

From Node	To Node	Reported Strength	P-Value	Null Hypothesis
S	A	3.484169e-02	P<0.01	Rejected
A	PRT	1.381442e-30	P<0.01	Rejected
A	PRV	8.541448e-50	P<0.01	Rejected
PRT	SFR	1.841834e-03	P<0.01	Rejected
PRV	SFR	1.851852e-03	P<0.01	Rejected
SFR	T	3.153902e-21	P<0.01	Rejected

The null hypothesis of conditional independence of all the arcs is rejected at $P<0.01$, thus confirming the conditional dependence of the child node to the parent nodes supported by the data. The structure of the proposed DAG model based on the theoretical concepts are valid. The arc present in the graph establishes that nodes in the structure of the DAG are directly related to the other nodes as represented in the graph.

Another method to validate the network structure is to measure the score gain/loss caused by the arc’s removal. In this the difference between the score of the network in which the arc is not present and the score of the network in which the arc is present is determined. Negative values correspond to decreases in the network score and positive values correspond to increases in the network score, stronger the relationship, the more negative the difference (Scutari & Denis, 2015).

Table 4: Score Gain/Loss Table by Arc’s Removal

From Node	To Node	Score Gain/Loss Caused by the Arc’s Removal
S	A	3.495855e-02
A	PRT	2.750081e-30
A	PRV	5.143770e-50
PRT	SFR	2.012161e-03
PRV	SFR	2.504000e-03
SFR	T	4.957076e-20

Table 4 presents the measure of the score gain/loss caused by the arc’s removal. The values in the third column correspond to no changes in the network score caused by the arc’s removal. Thus, all arcs in the network present the relationship between the nodes.

Parameter Estimation

The DAG and the observed parameter are used to estimate the Bayesian network parameter. Maximum-likelihood estimation is preferred when the DAG structure is already defined with full observability (Finn, 2001).

The bn.fit function of bnlearn package of R is used (Scutari & Denis, 2015) to estimate the parameter of the Bayesian network using maximum likely hood estimator “mle”.

The observed and estimated conditional probabilities associated with the nodes are given in the table from 5 to 14 for node A (awareness), PRT (protection), PRV (prevention), SFR (suffering) and T (treatment).

Table 5: Observed Conditional Probability Table for Node A

A	S		
	Broadcast	Print	Word of Mouth
Contaminated water	0.251	0.252	0.254
Contaminated food	0.223	0.236	0.204
Stomach infection	0.331	0.297	0.302
Unhygienic condition	0.195	0.215	0.240

Table 6: Estimated Conditional Probability Table for Node A

A	S		
	Broadcast	Print	Word of Mouth
Contaminated water	0.277	0.203	0.221
Contaminated food	0.220	0.294	0.231
Stomach infection	0.333	0.276	0.305
Unhygienic condition	0.168	0.225	0.241

Table 7: Observed Conditional Probability Table for Node PRT

PRT	A			
	Contaminated Water	Contaminated Food	Stomach Infection	Unhygienic Condition
Breast Feeding	0.323	0.313	0.584	0.462
Vitamin Supplements	0.346	0.456	0.321	0.430
Complimentary Food	0.331	0.231	0.095	0.107

Table 8: Estimated Conditional Probability Table for Node PRT

PRT	A			
	Contaminated Water	Contaminated Food	Stomach Infection	Unhygienic Condition
Breast Feeding	0.336	0.291	0.622	0.466
Vitamin Supplements	0.286	0.448	0.284	0.436
Complimentary Food	0.376	0.260	0.092	0.097

Table 9: Observed Conditional Probability Table for Node PRV

PRV	A			
	Contaminated Water	Contaminated Food	Stomach Infection	Unhygienic Condition
Safe drinking water	0.463	0.258	0.362	0.262
Cleanliness	0.301	0.418	0.208	0.219
Vaccination	0.115	0.114	0.407	0.120
Sanitation	0.121	0.210	0.023	0.399

Table 10: Estimated Conditional Probability Table for Node PRV

PRV	A			
	Contaminated Water	Contaminated Food	Stomach Infection	Unhygienic Condition
Safe drinking water	0.452	0.256	0.390	0.266
Cleanliness	0.257	0.410	0.183	0.233
Vaccination	0.152	0.106	0.396	0.124
Sanitation	0.137	0.226	0.030	0.375

Table 11: Observed Conditional Probability Table for Node SFR

PRV = Vaccination			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.439	0.411	0.409
5 - 15 days	0.283	0.323	0.350
More than 15 days	0.277	0.264	0.241
PRV = Cleanliness			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.385	0.535	0.500
5 - 15 days	0.333	0.338	0.399
More than 15 days	0.282	0.127	0.101
PRV = Safe drinking water			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.497	0.532	0.514
5 - 15 days	0.380	0.383	0.378
More than 15 days	0.23	0.085	0.108
PRV = Sanitation			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.500	0.511	0.495
5 - 15 days	0.336	0.356	0.356
More than 15 days	0.164	0.133	0.147

Table 12: Estimated Conditional Probability Table for Node SFR

PRV = Vaccination			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.448	0.427	0.375
5 - 15 days	0.282	0.330	0.400
More than 15 days	0.264	0.241	0.225
PRV = Cleanliness			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.338	0.515	0.15
5 - 15 days	0.274	0.346	0.363
More than 15 days	0.387	0.138	0.121
PRV = Safe Drinking Water			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.496	0.457	0.436
5 - 15 days	0.345	0.404	0.425
More than 15 days	0.158	0.138	0.137
PRV = Sanitation			
SFR	PRT		
	Vitamin Supplements	Breast Feeding	Complementary Feeding
1 to 4 days	0.587	0.522	0.468
5 - 15 days	0.225	0.363	0.319
More than 15 days	0.187	0.113	0.212

Table 13: Observed Conditional Probability Table for Node T

T	SUF		
	1 to 4 Days	5 to 15 Days	More than 15 Days
ORS	0.410	0.385	0.257
Homemade supplements	0.319	0.295	0.133
Antibiotic	0.151	0.193	0.295
Injection	0.120	0.127	0.315

Table 14: Estimated Conditional Probability Table for Node T

T	SUF		
	1 to 4 Days	5 to 15 Days	More than 15 Days
ORS	0.388	0.408	0.207
Homemade supplements	0.315	0.279	0.138
Antibiotic	0.182	0.192	0.324
Injection	0.112	0.119	0.329

Belief Updating

The purpose of the study is to evaluate the social marketing intervention IAPPD for Diarrhoea. The Bayesian network is used for drawing inference through the process of querying. Considering the Bayesian network as an expert system the questions mentioned below are asked in the form of conditional probability and we get the answer out of it (appendix. 1: Table 15). The *conditional probabilities queries* are estimated using “cpdist” of “bnlearn” package of R for prevention, protection and treatment variables under non-trivial conditioning.

Conditional probability query $Pr[PRV:PRT:T|S=S1]$ to investigate the most common prevention, protection and treatment measures for people whose source of information is Broadcast.

The distribution of prevention, protection and treatment measures presents that among people whose source of information is “broadcast” the most common prevention, protection and treatment measures preferred is “safe drinking water”, “breastfeeding” and “ORS”, respectively.

Conditional probability query $Pr[PRV:PRT:T|S=S2]$ to investigate the most common Prevention, Protection, and Treatment measures for people whose source of information is Print.

The distribution of prevention, protection and treatment measures presents that among people whose source of information is “Print” the most common prevention, protection, and treatment measures preferred is “safe drinking water”, “vitamin supplements” and “ORS”, respectively.

Conditional probability query $Pr[PRV:PRT:T|S=S3]$ to investigate the most common prevention, protection and treatment measures for people whose source of information is word-of-mouth.

The distribution of prevention, protection and treatment measures presents that among people whose source of information is “word-of-mouth” the most common prevention, protection and treatment measures preferred is “safe drinking water”, ‘breastfeeding’ and ‘ORS’ respectively.

Conditional probability query $Pr[PRV:PRT:T|A=A1]$ to investigate the most common prevention, protection and treatment measures for people who consider Contaminated food for the main cause of Diarrhoea.

The distribution of prevention, protection and treatment measures presents that among people who consider “Contaminated food” as the main cause of diarrhoea, for them the most common prevention, protection and treatment measures preferred is “Cleanliness/Hand wash”, “Vitamin supplements” and “ORS”, respectively.

Conditional probability query $Pr[PRV:PRT:T|A=A2]$ to investigate the most common prevention, protection, and treatment measures for people who consider Contaminated water for the main cause of Diarrhoea.

The distribution of prevention, protection and treatment measures presents that among people who consider “Contaminated Water” as the main cause of diarrhoea, for them the most common prevention, protection and treatment measures preferred is “Safe drinking water”, “Complementary food” and “ORS”, respectively.

Conditional probability query $Pr[PRV:PRT:T|A=A3]$ to investigate the most common prevention, protection, and treatment measures for people who consider Stomach infection for the main cause of Diarrhoea.

The distribution of prevention, protection, and treatment measures presents that among people who consider “Stomach infection” as the main cause of diarrhoea, for them the most common prevention, protection, and treatment measures preferred is “Safe drinking water”, “Breastfeeding” and “ORS”, respectively.

Conditional probability query $Pr[PRV:PRT:T|A=A4]$ to investigate the most common prevention, protection and Treatment measures for people who consider Unhygienic condition for the main cause of Diarrhoea.

The distribution of prevention, protection and treatment measures presents that among people who consider “Unhygienic Condition” as the main cause of diarrhoea, for them the most common prevention, protection, and treatment measures preferred is “Sanitation/Toilet facility”, “Breastfeeding” and “ORS”, respectively.

DISCUSSION

The present study evaluated the impact of IAPPD intervention programme on the preference of prevention measure, protection measure and treatment-seeking behaviour of the target population of the intervention area using Bayesian network analysis. The Bayesian network suggested for the study fit with the data well, establishing the causality of awareness of disease due to the broadcast, print and word-of-mouth campaign. The use of protection and prevention measures and treatment is the effect of practice and awareness of the caregiver. This finding is consistent with the findings of Kaur and Singh (2023) in evaluating anti-littering behaviour.

In particular, we found that the broadcast, print and word-of-mouth is effective in promoting the usage of “safe drinking water”, “breastfeeding”, “ORS”, “vitamin supplements”, “hand hygiene” and “sanitation” that is, caregiver effectively adopting six interventions out of ten intervention strategies promulgated by IAPPD. This finding is consistent with Muller (2023) supporting social action advertise for cause-oriented behaviour. It is also found that caregiver is being aware of various reasons for diarrhoea, and are taking appropriate steps to limit the widespread of disease, such as for whom the reason for causing diarrhoea is contaminated water took precautionary measures by seeking access to safe drinking water, similarly for those the contaminated food, unhygienic condition, are preferring “cleanliness” and “sanitation” as precautionary measures. This finding is consistent with Akbar et al. (2021) signifying importance of awareness for the success of social programme.

The evaluation analysis also showed that for caregiver having exposure of campaign through print associated with the use of “vitamin supplement” than the “breastfeeding” preferred by the caregiver informed through “broadcast” and/or “word-of-mouth” campaign. This finding is consistent with Muller (2023) supporting campaign for success of social marketing.

In the study, we found that the “ORS” is mostly preferred treatment for diarrhoea, as compared to homemade remedies, antibiotic and injection. This study supports the effectiveness of the ASHA workers to make available and to educate the caregiver about the preparation of ORS solution when needed. This finding is consistent with the

research finding of Kassegne et al. (2011) on evaluating social marketing intervention promoting oral rehydration salts in Burundi.

Over all in general for social marketing, our results are consistent with those obtained by other researchers (Curtis & Cairncross, 2003; Lakshminarayan & Jayalakshmy, 2015; Yewale, 2014, Kaur & Singh, 2023). In these studies, measures of prevention of Diarrhoeal disease emphasised the use of safe water, cleanliness, hygienic food, sanitation, anti-littering, breastfeeding and Vitamin A supplementation. The result of our study also provides evidence of the practice of the same by the caregiver to eliminate the occurrence of diarrhoea (Akbar et al., 2021). Poor sanitation, lack of access to clean water, and inadequate personal hygiene are responsible for maximum childhood diarrhoea (Lakshminarayan & Jayalakshmy, 2015; Kaur & Singh, 2023), handwashing is an important opportunity to prevent childhood diarrhoea (Curtis & Cairncross, 2003), our study provide evidence that caregivers are aware of them and taking appropriate measure to prevent the occurrence of it (Abuhussein & Magatef, 2023).

CONCLUSION

The limitation of this study is that it is based on recall of caregiver which would result in inaccurate reporting (Akbar et al., 2021). In spite of this, the findings of our study establish the best usage of measures of prevention, protection and treatment of Diarrhoeal disease through use of safe water, hand washing, hygienic food, sanitation and promoting breastfeeding, and use of ORS in case of illness. Thus, the IAPPD a social marketing programme is effective in promoting the measures of prevention, protection and treatment to reduce the incident of diarrhoea and diarrhoea-related mortality and morbidity of children (Akbar et al., 2023). This study would be helpful to project personnel to plan and evaluate their social marketing programme, to make it nimbler (Sturzaker, 2023).

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Appendix 1

Table 15: Joint Probability Distribution

Sr. No.	PRV	PRT	T	S1	S2	S3	A1	A2	A3	A4
1	PRV1	PRT1	T1	0.030	0.038	0.035	0.021	0.065	0.017	0.032
2	PRV1	PRT1	T2	0.021	0.029	0.025	0.020	0.044	0.011	0.025
3	PRV1	PRT1	T3	0.017	0.027	0.024	0.015	0.035	0.008	0.021
4	PRV1	PRT1	T4	0.016	0.010	0.018	0.015	0.033	0.010	0.016
5	PRV1	PRT2	T1	0.022	0.023	0.020	0.041	0.042	0.005	0.008
6	PRV1	PRT2	T2	0.017	0.021	0.016	0.027	0.029	0.004	0.006
7	PRV1	PRT2	T3	0.012	0.009	0.011	0.021	0.022	0.001	0.003
8	PRV1	PRT2	T4	0.006	0.007	0.006	0.014	0.016	0.001	0.002
9	PRV1	PRT3	T1	0.040	0.036	0.040	0.032	0.038	0.038	0.040
10	PRV1	PRT3	T2	0.027	0.034	0.028	0.019	0.032	0.031	0.029

Sr. No.	PRV	PRT	T	S1	S2	S3	A1	A2	A3	A4
11	PRV1	PRT3	T3	0.022	0.023	0.022	0.012	0.024	0.018	0.026
12	PRV1	PRT3	T4	0.022	0.018	0.017	0.010	0.017	0.019	0.012
13	PRV2	PRT1	T1	0.042	0.047	0.042	0.051	0.040	0.034	0.05
14	PRV2	PRT1	T2	0.041	0.027	0.035	0.032	0.035	0.025	0.034
15	PRV2	PRT1	T3	0.025	0.022	0.025	0.029	0.030	0.016	0.021
16	PRV2	PRT1	T4	0.015	0.020	0.016	0.016	0.010	0.017	0.018
17	PRV2	PRT2	T1	0.031	0.029	0.029	0.071	0.026	0.010	0.011
18	PRV2	PRT2	T2	0.024	0.022	0.020	0.054	0.015	0.009	0.006
19	PRV2	PRT2	T3	0.012	0.018	0.014	0.032	0.014	0.007	0.003
20	PRV2	PRT2	T4	0.012	0.005	0.009	0.024	0.008	0.006	0.004
21	PRV2	PRT3	T1	0.056	0.042	0.056	0.053	0.029	0.096	0.048
22	PRV2	PRT3	T2	0.041	0.036	0.038	0.044	0.022	0.079	0.039
23	PRV2	PRT3	T3	0.029	0.032	0.035	0.031	0.013	0.048	0.029
24	PRV2	PRT3	T4	0.018	0.022	0.024	0.024	0.010	0.033	0.021
25	PRV3	PRT1	T1	0.026	0.02	0.020	0.018	0.020	0.040	0.014
26	PRV3	PRT1	T2	0.035	0.016	0.019	0.014	0.012	0.025	0.019
27	PRV3	PRT1	T3	0.014	0.016	0.015	0.012	0.012	0.024	0.013
28	PRV3	PRT1	T4	0.013	0.011	0.010	0.006	0.006	0.022	0.006
29	PRV3	PRT2	T1	0.012	0.011	0.010	0.019	0.009	0.010	0.003
30	PRV3	PRT2	T2	0.010	0.006	0.008	0.011	0.007	0.009	0.000
31	PRV3	PRT2	T3	0.011	0.008	0.006	0.013	0.008	0.007	0.003
32	PRV3	PRT2	T4	0.006	0.004	0.004	0.008	0.001	0.007	0.000
33	PRV3	PRT3	T1	0.041	0.035	0.036	0.017	0.013	0.091	0.020
34	PRV3	PRT3	T2	0.035	0.028	0.030	0.013	0.006	0.066	0.012
35	PRV3	PRT3	T3	0.029	0.021	0.024	0.011	0.005	0.061	0.011
36	PRV3	PRT3	T4	0.015	0.020	0.018	0.007	0.006	0.039	0.011
37	PRV4	PRT1	T1	0.024	0.018	0.026	0.012	0.030	0.002	0.061
38	PRV4	PRT1	T2	0.019	0.021	0.018	0.010	0.032	0.002	0.038
39	PRV4	PRT1	T3	0.018	0.014	0.016	0.008	0.024	0.001	0.034
40	PRV4	PRT1	T4	0.012	0.013	0.010	0.003	0.015	0.000	0.022
41	PRV4	PRT2	T1	0.010	0.016	0.011	0.020	0.021	0.000	0.011
42	PRV4	PRT2	T2	0.018	0.004	0.008	0.012	0.015	0.000	0.011
43	PRV4	PRT2	T3	0.007	0.010	0.006	0.008	0.012	0.000	0.008
44	PRV4	PRT2	T4	0.005	0.005	0.006	0.007	0.009	0.000	0.006
45	PRV4	PRT3	T1	0.024	0.025	0.026	0.012	0.024	0.006	0.063
46	PRV4	PRT3	T2	0.019	0.024	0.019	0.012	0.021	0.005	0.046
47	PRV4	PRT3	T3	0.011	0.017	0.018	0.011	0.011	0.003	0.038
48	PRV4	PRT3	T4	0.006	0.008	0.011	0.005	0.010	0.004	0.023