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A comparison of total cost estimates between exclusive breast-feeding and breast milk substitute usage in humanitarian contexts

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Abstract

Objective: Using a model-based analysis, we calculated the total costs associated with the exclusive breast-feeding (EBF) and breast milk substitute (BMS) usage for one infant for six months within select humanitarian contexts to (a) determine if there is a notable difference in costs and (b) use these results to inform future creation of data-informed humanitarian response standard operating procedures.
Design: The inputs and costing data were drawn from a mixture of local e-commerce vendors, peer-reviewed literature and personal communications with field-based humanitarian responders. To account for cost fluctuations, each input's costs along with low and high parameters are presented. All costs are presented in 2021 United States Dollars.
Setting: Humanitarian responses within Indonesia and Jordan.
Participants: Not applicable.
Results: There was a notable difference in the total cost of care in both selected locations across the study arms (Indonesia: $542; Jordan: $892).
Conclusions: Given the reality of limited funding for comprehensive humanitarian response around the world and the necessity of prioritising certain interventions, humanitarian response organisations should consider the notable cost difference between EBF and BMS usage (along with the proven health benefits of EBF). This difference should play a role in informing the future creation of standard operating procedures while also ensuring that all infants within a humanitarian crisis receive appropriate feeding.

Keywords
Exclusive breast-feeding
Breast milk substitutes
Total costs
Humanitarian response
Infant feeding

Worldwide, the health benefits of exclusive breast-feeding (EBF) for infants under the age of six months are well documented, including reduced incidence rates of diarrhoeal illness and respiratory infections[1,2]. In disaster settings that require a humanitarian response, poor quality housing, population density, undernutrition and a range of other factors can increase the incidence of disease including diarrhoea and respiratory illness among infants and young children[3]. Efforts to improve infant and young child feeding practices in humanitarian contexts have sought to reduce disease burden and in turn, improve health outcomes.

The WHO and the UNICEF recommend that all children be exclusively breastfed for the first six months of life[4]. In 2017, the Infant and Young Child Feeding in Emergencies Core Group upheld this recommendation while adding that as part of a coordinated emergency response, humanitarian actors should seek to minimise the use of breast milk substitutes (BMS), including infant formula, other milk products and complementary foods, to contexts in which there is a documented need[5]. Furthermore, the Infant and Young Child Feeding in Emergencies Core Group's recommendations state that BMS and the requisite supplies should not be included in a general or blanket distribution to mothers with infants under the age of six months[5] and that instead provision of BMS should be done based on an individual assessment[6]. Despite these recommendations, humanitarian organisations do not always have a clear set of internal policies regarding how they determine which individuals should be provided with BMS, which can result in the uncontrolled and unmonitored distribution of BMS for infants under the age of six months during humanitarian emergency responses[7].

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The use of BMS may be indicated in circumstances where breast-feeding is limited or not occurring whether due to insufficiency of milk supply, death of a mother, inability of the child to suckle or latch, or for other reasons[5]. In such circumstances, the costs of BMS provision may require considerable resources which must then be covered by caregivers and their households, humanitarian actors and/or the larger health system[8].

In this paper, we model the economic costs of EBF and BMS feeding options for internally displaced persons up to six months of age in the Republic of Indonesia (hereafter referred to as Indonesia) and Syrian refugee children up to the age of six months in the Hashemite Kingdom of Jordan (hereafter referred to as Jordan). Efforts to estimate the total cost of alternative feeding strategies aim to facilitate resource planning and catalyse discourse on strategies for improving infant feeding outcomes during humanitarian responses.

Methods

Setting

In Indonesia, for every 100 children born alive 3·2 will die prior to reaching their fifth birthday[9] with neonatal disorders, diarrhoeal diseases and respiratory infections attributed as the leading causes of death[10]. In 2018, an estimated 31 % of children under 5 years of age were stunted and 10 % were wasted[11]. Over the same time period, more than half of children (52 %) were exclusively breastfed for the first six months of life and 77 % partially breastfed throughout their first year of life[9]. The median duration of EBF and predominant breast-feeding was 3 months and 3·8 months, respectively. Children in the lowest socioeconomic strata, whose mothers have no education or who reside in rural areas, are breastfed longer. Good infant feeding practices are often upended in the contexts of humanitarian emergencies. Humanitarian responses in Indonesia are mostly the result of natural disasters as Indonesia is considered a high-risk country for natural disasters with the Indonesian government estimating that 97 % of the population lives in disaster-prone areas[12]. Examples of major disasters include the Indian Ocean Tsunami (2004), the Yogyakarta and Central Java earthquake (2006) and the Sulawesi region earthquake and tsunami (2018). These events and the like have had catastrophic effects on health systems and routine health services delivery with the Internal Displacement Monitoring Centre estimating that approximately 378 000 Indonesians are internally displaced annually due to natural disasters[13]. To facilitate planning for such events, we model the costs of EBF and alternative feeding strategies for one internally displaced infant in Indonesia.

In Syria, trends in child health and infant feeding are harder to understand given the paucity of data borne by years of ongoing conflict since the start of the civil war in 2011, which has caused over 5·5 million civilians to flee as refugees. As of March 2023, the United Nations High Commissions for Refugees reports that over 660 000 Syrian refugees were officially registered within Jordan with an estimated 81 % of these refugees residing within host communities while approximately 116 000 refugees reside within established refugee camps, mostly the Azraq and Za'atri refugee camps[14]. In 2016, an estimated range of 6·4–19·2 % of children between 6–59 months were stunted, depending on their location within Jordan in either the host communities or Azraq refugee camp[15]. Over the same time period, an estimated 19 % of infants in the host communities and 54 % of infants within Za'atri refugee camp were exclusively breastfed for the first six months of life while it was reported that an estimated 29 % of infants within host communities and 4 % of infants within Za'atri refugee camp had consumed BMS in the previous 24 h[15]. Due to the ongoing response to the Syrian refugee population within Jordan and the lower levels of EBF, we model the costs of EBF and alternative feeding costs for one Syrian refugee infant.

Infant feeding options

We model the total costs of two infant feeding options, EBF and exclusive use of BMS for one infant for a period of six months. It is acknowledged that infants who are not exclusively breastfed are not guaranteed to be exclusively fed BMS but rather may subsist on water, tea, cow's or goat's milk. However, within our cost modelling, we modelled for either 100 % EBF or 100 % BMS usage in order to create broadly applicable total cost estimates.

Economic costs

Economic costs were assessed from a societal perspective and included all costs associated with EBF or BMS for one infant over a six-month period in each site. Table 1 outlines the estimated inputs required by the feeding method, as well as associated assumptions and data sources. Capital costs were defined as one-time inputs with the life expectancy of greater than one year, while recurrent costs were those inputs with a life expectancy of less than one year. Costs were drawn from three sources: e-commerce vendors based on each setting, peer-reviewed literature and humanitarian professionals in the field. The amount of water required for BMS preparation and use was divided between tap water and bottled water for the low-, mid- and high-level estimates. The low- and mid-level requirements were calculated in consultation with humanitarian professionals in the field while the high-level requirements were based on Gribble and Berry[8], and a detailed breakdown of all calculations is available in Supplementary material.

As available, this study presents the costs for each input along with low and high parameters for each input. International Monetary Fund consumer price indices were used to adjust all prices to 2021 United States Dollars (USD)

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Table 1 Description of inputs for exclusive breast-feeding and breast milk substitute use

Inputs	Description	Type of cost	Source
Study arm 1: Exclusive breast-feeding for 6 months			
Salary costs for Community Health Worker (CHW) to provide lactation counselling to caregiver	The total salary costs of a CHW to provide a series of 30-minute long consultation sessions per lactating caregiver in order to ensure that lactating caregivers know how to properly breastfeed infants and to answer any questions that the caregivers may have. The total number of consultation sessions could vary from four to six.	Capital	Source for Input: Personal communication with Jardeneh, D with the UNHCR in 2020. Source for Cost: Personal communication with Jardeneh, D with the UNHCR in 2020, 20
Additional bottled water for lactating caregiver	The 127·4 liters (l) of additional bottled water that should be consumed by the lactating caregiver over the course of the six months, with an average 0·7 l per day. It is presumed that this water would be the equivalent of treated bottled water.	Recurrent	Source for Input: 21 Source for Cost: 22, 23
Additional food for lactating caregiver	The 182 days worth of additional food (totalling 500 kcal worth daily) that should be consumed by the lactating caregiver.	Recurrent	Source for Input: 24 Source for Cost: 25, 26
Mastitis treatment	Indonesia and Jordan: the total number of episodes ranges from 0·1–0·3 with 0·2 episodes as the average number per caregiver Treatment cost estimations were budgeted as a 30-minute consultation with a CHW to receive advice on massaging and applying warm compresses to the infected area.	Recurrent	Source for Incidence: 27 Source for Cost: Personal communication with Jardeneh, D with the UNHCR in 2020, 20
Diarrhoeal disease treatment	Indonesia: the total number of episodes ranges from 0·51–0·63 with 0·57 episodes as the average number per infant. Jordan: the total number of episodes ranges from 0·36–0·45 with 0·41 episodes as the average number per infant. Protective effect of exclusive breast-feeding against diarrhoeal disease incidence among infants is calculated at 63 % and this is accounted for in the total number of episodes referenced above. Treatment ranges from at-home treatment costs to treatment via an outpatient consultation to in-patient hospital stays. The costs given represent the average of those options.	Recurrent	Source for Incidence: 10 Source for Protective Effect: 1 Source of Cost: 2
Acute respiratory illness (ARI) treatment	Indonesia: the total number of episodes ranges from 3·53–4·41 with 3·95 episodes as the average number per infant Jordan: the total number of episodes ranges from 1·87–3·16 with 2·48 episodes as the average number per infant Protective effect of exclusive breast-feeding against ARI incidence among infants is calculated at 32 % and this is accounted for in the total number of episodes referenced above. Treatment ranges from at-home treatment costs to treatment via an outpatient consultation to in-patient hospital stays. The costs given represent the average of those options.	Recurrent	Source for Incidence: 10 Source for Protective Effect: 1 Source of Cost: 2
Study arm 2: Breast milk substitute use for 6 months			
Basic preparation materials	The basic materials required to prepare BMS including a cooking pot with lid for sterilising the preparation equipment, measuring cups, serving tongs and stirring spoons.	Capital	Source for Input: 8 Source for Cost: 28, 29, 30, 31, 32, 33, 34
Feeding bottles	Two reusable feeding bottles per caregiver who is relying on BMS to feed the infant. These feeding bottles include the attached nipple needed to facilitate infant feeding.	Capital	Source for Input: 9, Personal communication with Jardeneh, D with the UNHCR in 2020. Source for Cost: 35, 36

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Table 1 *Continued*

Inputs	Description	Type of cost	Source
Gas stove	One gas stove per caregiver in order to prepare the BMS. It is assumed that the gas stove required for BMS usage would not solely be used for BMS preparation. Therefore, the total cost estimates only attribute 10 % of the gas stove's cost to BMS usage.	Capital	Source for Input: 8, Personal communication with Jardeneh, D with the UNHCR in 2020. Source for Cost: 37, 38
Salary costs for CHW to provide the caregiver with instructions on how to correctly prepare and use BMS.	One 30-minute long consultation session provided via CHW to BMS users to ensure safe preparation of BMS.	Recurrent	Source for Input: Personal communication with Jardeneh, D with the UNHCR in 2020. Source for Cost: Personal communication with Jardeneh, D with the UNHCR in 2020, 20
Formula tin	Fifty-two (52) 900 g formula tins required to provide an infant with BMS for a six-month period.	Recurrent	Source for Input: 8 Source for Cost: 2, 39, 40, 41, 42, 43
Bottled water	The total amount of bottled water required for each individual caregiver to prepare the BMS over a period of six months. This total amount ranges from 123–3549 l. This study arm distinguished between bottled water and tap water to account for situations in which there is working, accessible plumbing infrastructure with the total amounts calculated based on the authors' experiences and conversations with other professionals. The detailed breakdown of these calculations can be found in Supplementary Table 1.	Recurrent	Source for Input: 8, Personal communication with Gribble, K from the Western Sydney University School of Nursing and Midwifery in 2021. Source for Cost: 22, 23
Tap water	The total amount of water required for each individual user to prepare for feeding with BMS over a period of six months. This total amount ranges from 2721–3135 l. This study arm distinguished between bottled water and tap water to account for situations in which there is working, accessible plumbing infrastructure with the total amounts calculated based on the authors' experiences and conversations with other professionals. The detailed breakdown of these calculations can be found in Supplementary Table 1.	Recurrent	Source for Input: 8, Personal communication with Gribble, K from the Western Sydney University School of Nursing and Midwifery in 2021. Source for Cost: 44, 45
Liquid petroleum gas (LPG)	The total amount of LPG required to power the gas stove which would be used to properly prepare the BMS by bringing the water from a standing temperature of 20°C to 100°C and then maintaining that temperature for five minutes to ensure sterilisation. This total amount ranges from 22–160 kg. This is calculated based on each litre of water which requires heating requiring 45 g of LPG, with the total amounts of water requiring heating ranging from 487–3549 l.	Recurrent	Source for Input: 8, 45, Personal communication with Schweitzer, R from the Centers for Disease Control and Prevention in 2021 Midwifery in 2021. Source for Cost: 47, 48
Diarrhoeal disease treatment	Indonesia: the total number of episodes ranges from 1·39–1·70 with 1·55 episodes as the average number per infant. Jordan: the total number of episodes ranges from 0·99–1·20 with 1·10 episodes as the average number per infant Treatment ranges from at-home treatment costs to treatment via an outpatient consultation to in-patient hospital stays. The costs given represent the average of those options.	Recurrent	Source for Incidence: 10 Source of Cost: 2

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Table 1 *Continued*

Inputs	Description	Type of cost	Source
ARI treatment	Indonesia: the total number of episodes ranges from 5·19–6·48 with 5·81 episodes as the average number per infant. Jordan: the total number of episodes ranges from 2·75–4·65 with 3·64 as the average number per infant. Treatment ranges from at-home treatment costs to treatment via an outpatient consultation to in-patient hospital stays. The costs given represent the average of those options.	Recurrent	Source for Incidence: 10 Source of Cost: 2

to facilitate the comparison of results across settings and time periods of individual price collection. The cost standardisations were done by applying the consumer price indices in the original currency of the input and then converting the resultant price into United States Dollars based on the average 2021 exchange rates[16–19].

Sensitivity analyses

In order to calculate an accurate total cost estimate for both study arms (EBF and exclusive BMS use), we calculated the low and high parameters for each input in order to account for cost fluctuations that occur in free markets and these results are presented in online supplementary material, Supplemental Tables 2 and 3.

Disease incidence

In our total cost calculations, we included average treatment costs for certain infections that are either directly linked to EBF such as mastitis in breast-feeding caregivers as well as infections in infants that EBF is known to protect against: diarrhoeal disease and acute respiratory infections (ARI)[1,2,27]. These treatment costs for each infection were the average cost of care per infectious episode.

Assumptions

We assumed that the basic infrastructure for a humanitarian response was already in place including shelter for the affected population, the logistics systems required for the transit of hard goods including food rations and formula tins, a functioning water supply system and a basic health system operating within SPHERE standards. If some or none of these systems are operable and require establishment, then the total costs for each infant feeding model would increase. Modelled total costs include feeding bottles under the BMS usage study arm, despite the recommendation by experts for cup feeding as bottle-feeding is still more widely practised in the field. Additional costs associated with hand soap and/or cleaning detergent required for BMS preparation were not included because these are already part of the standard supplies given in humanitarian responses. Finally, it was assumed that there would be no bulk rate discount for any of the materials purchased in any of the settings although there is the potential for such discounted prices depending on the location where the goods are purchased, which actors are bearing the costs and the overall amount purchased.

Ethics

This is a model-based analysis which draws upon available literature and thus is exempt from institutional review board clearance.

Results

In Tables 2 and 3, we present the detailed breakdown of the total costs of care for a single infant for a total of six months via either EBF or through the exclusive use of BMS among internally displaced persons in Indonesia and Syrian refugees living in Jordan, respectively. Within online supplementary material, Supplemental Tables 2 and 3, we present the results of the sensitivity analysis which used high-cost and low-cost inputs and which demonstrated that regardless of what level of costs are used, the results detailed below remain the same.

The total cost of feeding care for one internally displaced infant for six months in Indonesia was US $148 ($25/month) in the EBF study arm and $690 ($115/month) in the BMS arm, corresponding to a difference in cost of US $542 across study arms. In the EBF arm, the leading cost drivers were ARI treatment (3·95 episodes; 48 % of total costs), additional water for breast-feeding caregivers (25 %), additional food for breast-feeding caregivers (14 %), salary costs for lactation consultation (2·5 h; 9 % total costs) and diarrhoeal disease treatment (0·57 episodes; 3 % of total costs). In the BMS arm, 69 % of total costs were attributed to formula (52 tins), followed by ARI treatment (5·81 episodes; 15 % of total costs), preparation materials (6 %), bottled water (5 %), diarrhoeal disease treatment (1·55 episodes; 2 % of total costs) and petroleum gas costs to boil water (1 %).

The total cost of feeding care for one Syrian refugee infant for six months in Jordan was US $181 ($30/month) in the EBF study arm and $1073 ($179/month) in the BMS arm; corresponding to a difference in cost of US $892 across

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Table 2 Total costs of feeding care for one internally displaced infant for 6 months in Indonesia

Item	Total units	Unit cost (2021 USD)	% of use attributed to the programme	Total cost (2021 USD)	% of total cost
Study arm 1: Exclusive breast-feeding for 6 months					
Salary costs for CHW to provide lactation consultation sessions to the caregiver	2·5 h	$5·34 per hour	100 %	$13·35	9 %
Additional water for lactating caregiver	127·4 l	$0·44 per 1·5 litre bottle	100 %	$37·37	25 %
Additional food for lactating caregiver	182 d	$0·11 per day	100 %	$20·02	14 %
Mastitis treatment	0·2 episodes	$2·67 per episodic treatment	100 %	$0·53	0 %
Diarrhoeal disease treatment	0·57 episodes	$8·90 per episodic treatment	100 %	$5·07	3 %
ARI treatment	3·95 episodes	$18·14 per episodic treatment	100 %	$71·65	48 %
Total study arm 1				$148·00	
Study arm 2: Breast milk substitute use for 6 months					
Basic preparation materials	1 set	$38·06 per set	100 %	$38·06	6 %
Feeding bottles	2 bottles	$2·56 per bottle	100 %	$5·12	1 %
Gas stove	1 stove	$43·07 per stove	10 %	$4·31	1 %
Salary costs for CHW to provide training session on how to correctly prepare and use BMS to caregiver.	0·5 h	$5·34 per hour	100 %	$2·67	0 %
Formula tin (900 g)	52 tins	$9·18 per tin	100 %	$477·36	69 %
Bottled water	123 l	$0·44 per 1·5 litre bottle	100 %	$36·08	5 %
Tap water	3135 l	$0·07 per cubic metre	100 %	$0·22	0 %
LPG	22 kg	$0·31 per kilogram	100 %	$6·82	1 %
Diarrhoeal disease treatment	1·55 episodes	$8·90 per episodic treatment	100 %	$13·80	2 %
ARI treatment	5·81 episodes	$18·14 per episodic treatment	100 %	$105·39	15 %
Total study arm 2				$689·82	

Table 3 Total costs of feeding care for one Syrian refugee infant for 6 months in Jordan

Item	Total units	Unit cost (2021 USD)	% of use attributed to programme	Total cost (2021 USD)	% of total cost
Study arm 1: Exclusive breast-feeding for 6 months					
Salary costs for CHW to provide lactation consultation sessions to the caregiver	2·5 h	$2·14 per hour	100 %	$5·35	3 %
Additional water for lactating caregiver	127·4 l	$0·57 per 1·5 litre bottle	100 %	$48·41	27 %
500 kcal of additional food for breast-feeding caregiver	182 d	$0·11 per day	100 %	$20·02	11 %
Mastitis treatment	0·2 episodes	$1·07 per episodic treatment	100 %	$0·21	0 %
Diarrhoeal disease treatment	0·405 episodes	$9·26 per episodic treatment	100 %	$3·75	2 %
ARI treatment	2·48 episodes	$41·54 per episodic treatment	100 %	$103·02	57 %
Total study arm 1				$180·77	
Study arm 2: Breast milk substitute use for 6 months					
Basic preparation materials	1 set	$54·95 per set	100 %	$54·95	5 %
Feeding bottles	2 bottles	$13·58 per bottle	100 %	$27·16	3 %
Gas stove	1 stove	$56·45 per stove	10 %	$5·65	1 %
Salary costs for CHW to provide training session on how to correctly prepare and use BMS to caregiver	0·5 h	$2·14 per hour	100 %	$1·07	0 %
Formula tin (900 g)	52 tins	$13·58 per tin	100 %	$706·16	66 %
Bottled water	123 l	$0·57 per 1·5 litre bottle	100 %	$46·74	4 %
Tap water	3135 l	$16·68 per cubic metre	100 %	$52·29	5 %
Liquid petroleum gas	22 kg	$0·80 per kilogram	100 %	$17·60	2 %
Diarrhoeal disease treatment	1·095 episodes	$9·26 per episodic treatment	100 %	$10·14	1 %
ARI treatment	3·64 episodes	$41·54 per episodic treatment	100 %	$151·21	14 %
Total study arm 2				$1072·96	

Table 4 Total cost of care for a single Indonesian infant using mixed feeding methods for 6 months

Feeding method mix (in months)	EBF: 6 BMS use: 0	EBF: 5 BMS use: 1	EBF: 4 BMS use: 2	EBF: 3 BMS use: 3	EBF: 2 BMS use: 4	EBF: 1 BMS use: 5	EBF: 0 BMS use: 6
Total cost	$148·00	$238·30	$328·61	$418·91	$509·22	$599·52	$689·82
Cost savings with each additional month of EBF	$541·80	$451·50	$361·20	$270·90	$180·60	$90·30	$0

Table 5 Total cost of care for a single Syrian refugee infant in Jordan using mixed feeding methods for 6 months

Feeding method mix (in months)	EBF: 6 BMS use: 0	EBF: 5 BMS use: 1	EBF: 4 BMS use: 2	EBF: 3 BMS use: 3	EBF: 2 BMS use: 4	EBF: 1 BMS use: 5	EBF: 0 BMS use: 6
Total cost	$180·77	$329·46	$478·16	$626·86	$775·56	$894·14	$1072·96
Cost savings with each additional month of EBF	$892·20	$743·50	$594·80	$446·10	$297·40	$148·70	$0

study arms. In the EBF arm, the leading cost drivers were ARI treatment (2·48 episodes; 57 % of total costs), additional water for breast-feeding caregivers (27 %), additional food for breast-feeding caregivers (11 %), salary costs for lactation consultation (2·5 h; 3 % total costs) and diarrhoeal disease treatment (0·41 episodes; 2 % of total costs). In the BMS arm, 66 % of total costs were attributed to formula, followed by ARI treatment (3·64 episodes; 14 % of total costs), preparation materials (5 %) and tap water (5 %), bottled water (4 %), feeding bottles (3 %), petroleum gas costs to boil water (2 %) and diarrhoeal disease treatment (1·10 episodes; 1 % of total costs).

The results in both study locations consistently show a difference in higher total cost of care in the BMS study arm even when we applied the sensitivity analyses with low- and high-cost inputs. The explicit details from each sensitivity analysis can be viewed in online supplementary material, Supplemental Tables 2 and 3.

Given the entirely plausible reality that an infant born amid an ongoing humanitarian emergency response could be subject to a mixed feeding method, in which the infant receives EBF for a few months of its life before the caregiver switches to BMS use, it is important to understand the cost savings that accrue with each additional month of EBF. This information is visually displayed below in Tables 4 and 5. Results suggest that for each month that an infant is exclusively breastfed rather than a recipient of BMS, there is an average cost savings of $90 in Indonesia and $149 in Jordan. For example, if there was a scenario in which an infant is exclusively breastfed for five months and receives BMS for 1 month, this would correspond to a total cost of $238 in Indonesia and $330 in Jordan.

Discussion

This study considered the total cost of two infant feeding strategies, EBF and BMS use, as part of a larger humanitarian response for Syrian refugee infants in Jordan and internally displaced infants in Indonesia. Regardless of the humanitarian response setting, the findings suggest a demonstrable higher cost associated with BMS use for six months as compared to EBF for six months (4·66 times higher in the Indonesian setting and 5·94 times higher in the Syrian refugee setting). Additionally, this study calculated that there would be associated cost savings for every additional month of EBF in lieu of BMS use if a mixed feeding method were to be used during that period.

The consequential accrual of any cost savings due to having one additional infant receive EBF for one additional month could potentially be re-invested in other health interventions. For example, based on the average monthly difference between the base costs among the Syrian refugees living in Jordan ($149 United States Dollars), using the cost savings of one infant receiving one additional month of EBF, the responding health system and humanitarian organisations could purchase approximately 345 single-dose measles vaccines (if the vaccines in question were purchased at the 2021 UNICEF procurement price)[49]. If this cost difference was expanded to cover the entire six-month period ($892), a total of approximately 2074 single-dose measles vaccines could be purchased, which is important given that the measles vaccine is one of the most important vaccines that is distributed during a humanitarian response. Additionally, other meaningful re-investments could be the provision of lactation counselling and maternal mental health services but importantly, cost savings would not have to be exclusively directed into health interventions but could also be used to help fund non-health aspects of a humanitarian response such as livelihood or education programmes. Notably, regardless of the location, these cost savings and the consequential potential for other uses are calculated only for the single infant. Yet, in the case of a humanitarian response, it is likely there will be a large population of infants thus creating the potential for magnified cost savings or cost

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expenditures depending on whether the infants in question are exclusively breastfed or reliant on provided BMS.

Based on the financial implications of the provision of BMS in a humanitarian response, a clear recommendation emerges for humanitarian organisations to encourage any caregiver who either gives birth during a humanitarian response or who already has an infant and is capable of breast-feeding, to exclusively breastfeed the infant in question. This is in no way a recommendation to deny BMS to infants whose caregivers are unable or unwilling to exclusively breastfeed or infants who are without caregivers at all. It is also important to note that this study did not delve into the bioethics of the appropriate mechanisms (if any) to persuade a caregiver in a humanitarian emergency to exclusively breastfeed an infant in their care if they are able.

The intent of this study was to add to the global discussion of resource planning during humanitarian responses given the limited amounts of total response funding as well as the demonstrable total cost differences between EBF of an infant under the age of six months and the provision of BMS to an infant in the same period. To the authors' knowledge, this is the first study to estimate the total costs associated with both feeding strategies on an individual level in humanitarian response scenarios. However, this study builds on the findings from the Alive & Thrive Cost of Not Breastfeeding tool[50] and related publications[8], which estimated the total systems costs associated with not breast-feeding for various countries, including Indonesia, using systematic reviews and meta-analyses. Similar to these studies, we found that the costs of not breast-feeding (i.e. reliance on BMS) were significantly higher than EBF but we were able to provide direct comparisons across study arms in the selected locations.

Limitations

Study findings are limited by the absence of primary data. Cost estimates were drawn from the literature, e-searches and personal communications with field-based humanitarian professionals. Where possible we have sought to include the full spectrum of costs likely to be incurred by beneficiaries, programme partners and the health system in these contexts. However, we note that modelled cost estimates do not include lost-labour opportunity costs for caregivers in either intervention arm. The reasoning for this exclusion was twofold: that the availability of formal paid work opportunities in either setting was deemed to be very low during a humanitarian response and that because these costs were excluded in both infant feeding models, neither model was more impacted than the other. Additionally, the study did not delve into a deeper understanding of which actors bear the cost of each input for EBF and BMS usage as in reality, these costs would probably be shared between responding humanitarian organisations, local health facilities and the caregivers and their families themselves. This decision was taken given that this division can vary based on setting and the study sought to examine the total costs of care regardless of the actor who bore the cost. Finally, the cost estimates were calculated using the same average use of inputs for each month despite the understanding that consumption of inputs will change over the course of six months as an infant grows. Consequently, the average cost differences may actually be larger between the EBF study arm and BMS usage study arm in later months as more formula, water and other inputs are used.

Conclusions

As humanitarian responders and government partners continue to respond to humanitarian emergencies around the world and decide how to best prioritise the available funding, it is necessary to look at all activities and analyse the true cost implications of those decisions[51]. The information from these total cost estimations of EBF *v.* BMS use among infants between the ages of zero to six months can help to inform these decisions as even one additional month of EBF for one infant can have noticeable cost savings. Furthermore, prior studies have established that higher rates of EBF will result in the prevention of death in children under five years. Among women, EBF has additionally been shown to be protective against the incidence of breast and ovarian cancers in breast-feeding caregivers[1]. In summary, while all infants within a humanitarian crisis should receive appropriate feeding, humanitarian response organisations should consider these cost differences along with the proven health benefits of EBF for infants under the age of six months in order to best create standard operating procedures for how to best address this issue moving forward.

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Authorship

Z.K.M. and M.V. formulated the research questions. Z.K.M. sourced most of the input data from secondary and e-

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commerce sources while M.V. sourced the data from primary sources, Z.K.M. and M.V. selected the settings for comparison and co-wrote the introduction and conclusion sections. A.L. and Z.K.M. conducted the data analyses and co-wrote the methods section of the manuscript. Z.K.M., M.V. and A.L. co-wrote the results and discussion section.

Ethics of human subject participation

Not applicable, research did not involve human participants.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980023002434

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