BMJ Global Health

The 'Health-2-Go' programme's impact on all-cause mortality and clinic utilisation for children 5 and under: a retrospective cohort analysis of an iCCM intervention in Ghana's Barekese Subdistrict

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To cite: Guynn I, Hassmiller Lich K, Manortey S, *et al*. The 'Health-2-Go' programme's impact on all-cause mortality and clinic utilisation for children 5 and under: a retrospective cohort analysis of an iCCM intervention in Ghana's Barekese Subdistrict. *BMJ Glob Health* 2025;**10**:e017786. doi:10.1136/bmjgh-2024-017786

Handling editor Naomi Clare Lee

Received 8 October 2024
Accepted 26 February 2025

Check for updates

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ABSTRACT

Introduction The 'Health-2-Go' programme, which incorporates the integrated community case management strategy, aims to enhance healthcare access in rural Ghana by deploying trained and equipped community-based agents to manage the diagnosis and treatment of basic illness for children aged 5 and under. This study evaluates the intervention's impact on all-cause mortality and clinical healthcare utilisation among children 5 and under in the Barekese Subdistrict in the Atwima Nwabiagya North District of the Ashanti Region of Ghana.

Methods A retrospective cohort study was conducted using data from 2530 children across nine communities exposed to Health-2-Go and six comparison communities with no Health-2-Go exposure. Child mortality data were collected via a verbally administered household census, and clinical healthcare utilisation data were extracted from clinic records. We used Cox proportional hazards regression models to estimate the impact of exposure to Health-2-Go on child mortality and negative binomial regression models to assess exposure to Health-2-Go on changes in 5 and under clinic visits resulting in a malaria diagnosis.

Results Exposure to Health-2-Go was significantly associated with a 67.7% reduction in the hazard of death (*HR=0.323; p=0.015; 95% CI 0.130, 0.803*). The programme's impact on healthcare utilisation showed a significant 83% reduction in unnecessary clinic visits for uncomplicated malaria among children 5 and under (*IRR=0.17; p=0.027; 95% CI 0.04, 0.82*). No significant association was found between programme exposure and the expected number of clinic visits for severe malaria among children 5 and under.

Conclusions The Health-2-Go programme demonstrates substantial potential in reducing child mortality and improving healthcare access in low-resource and 'hard-to-reach' settings in rural Ghana. Further prospective research is recommended to confirm these findings and explore the long-term sustainability of the programme.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Integrated community case management (iCCM) strategies have been implemented in various low-resource settings to reduce child mortality and improve healthcare access, with mixed results depending on the effectiveness of implementation models.

WHAT THIS STUDY ADDS

⇒ This study provides evidence that the 'Health-2-Go' programme, which incorporates the iCCM strategy through community-based agents, significantly reduces all-cause mortality and clinic visits for uncomplicated malaria among children 5 and under in rural and hard-to-reach communities of Ghana's Barekese Subdistrict.

⇒ The findings highlight the programme's potential to shift the burden of care from overstretched health facilities to community settings while improving child health outcomes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study's results suggest that scaling up the 'Health-2-Go' programme could enhance healthcare delivery and reduce child mortality in similar low-resource settings.

⇒ Policymakers and health practitioners may consider adopting and adapting the 'Health-2-Go' model to strengthen community-based healthcare systems. However, additional prospective research on the 'Health-2-Go' programme and its implementation is merited.

INTRODUCTION

Healthcare systems in West Africa's low- and middle-income settings face persistent challenges, characterised by limited resources and a demand for healthcare that surpasses the existing capacity.[1 2] Such is the case in Ghana, where the healthcare system is marked by a combination of constrained resources and an overwhelming demand for healthcare services.

Notable disparities in access to quality care are evident in Ghana, especially in rural and hard-to-reach regions.[3 4] The first tier of Ghana's healthcare system is organised at the community level, with compounds known as Community-Based Health Planning and Services (CHPS) and subdistrict health centres providing basic primary care services.[5] For more specialised care, Ghana's public hospital system is organised into district hospitals (serving about 200 000), regional hospitals (serving about 1.2 million) and tertiary or teaching hospitals (five in total).[6] The Ghana Health Service reports regional disparities in healthcare infrastructure, with urban areas benefiting from more extensive facilities compared with rural counterparts.[6] Additionally, Ghana contends with a shortage of healthcare professionals, which is evident in the physician density of approximately 1.4 doctors per 10 000 people, underscoring the strain on the system to meet the healthcare needs of its population.[7 8]

Escalating healthcare demand, driven by population growth and epidemiological transitions, poses a significant burden on the health system, leading to challenges in ensuring timely and equitable healthcare delivery.[9 10] The impact of these system challenges is illustrated by Ghana's under-5 mortality and the leading causes of under-5 death. Based on 2020 data, Ghana needs to reduce its under-5 mortality rate by nearly 50% to meet the 2030 Sustainable Development Goal of no more than 25 deaths per 1000 live births.[11 12] Under-5 mortality serves as a meaningful and comprehensive metric of health system performance due to its sensitivity to a range of factors that directly reflect the effectiveness and accessibility of healthcare services.[13] This metric encapsulates the impact of interventions related to maternal and child health, vaccination programmes and the management of common childhood illnesses.[14] The well-being of children during this vulnerable time in their lifespan is indicative of the overall health of a population.[15] Because this well-being is influenced both by healthcare access and by broader socioeconomic conditions, when reductions in the mortality rate are seen in this age group, it signifies broader advancements in a population's living conditions, the success of preventive measures and the overall performance of healthcare systems.[16]

Most under-5 deaths in Ghana are attributed to malaria, pneumonia and diarrhoea.[17] These communicable diseases are largely preventable and treatable with low-cost interventions, including vaccinations, proper sanitation and timely medical care.[18–20] Their prominent contribution to Ghana's under-5 mortality highlights the potential for targeted interventions to save lives. The prevalence of these diseases emphasises the need for and importance of a well-functioning healthcare system with accessible and quality services, particularly in remote or underserved areas. Effective primary healthcare can significantly reduce mortality from these conditions.[21 22]

The 'Health-2-go' programme in Ghana

The 'Health-2-Go' programme, which incorporates the WHO/United Nations Children's Fund's integrated community case management (iCCM) strategy,[23] is a set of integrated approaches that brings basic health services to remote, underserved communities through trained and equipped community-based agents (CBAs).[24 25] Health-2-Go is designed to support the redistribution of healthcare resources such that the highest volume of healthcare can be delivered in the community setting, keeping costs and severity of disease low, and higher levels of healthcare (*ie, CHPS, subdistrict health centres*) can be reserved for referrals or acute needs beyond the scope of a CBA.[24 25] Through this intervention, community-selected CBAs are trained to (1) deliver home-based health education; (2) manage, under direct clinical supervision, the diagnosis and treatment of basic illness of children aged 0–5 years following iCCM guidelines and (3) connect complicated illnesses to health facilities through referrals. The implementation package of Health-2-Go was developed and piloted between 2016 and 2018 in six communities in the Wawase CHPS Zone in the Lower Manya Krobo Municipality in the Eastern Region of Ghana (comprising a population of about 1500 people, with about 200 under the age of 5).[24 25] From 2019, Health-2-Go has been fully implemented in 16 rural communities (comprising a population of about 20 000 people, with about 2200 under the age of 5) all located in the Barekese Subdistrict, which is in the Atwima Nwabiagya North District of the Ashanti Region.[24 25] To date, Health-2-Go has maintained consistent schedules for refresher trainings, a high level of community engagement, and clear alignment with Ghana Health Service.[24 25] Programmatic evaluation data from this limited-scale Barekese Subdistrict demonstration suggest that the 28 CBAs trained by Health-2-Go have remained actively engaged in the intervention, and utilisation of services persists.[24 25] Stakeholders, including local community leaders and Ghana Health Service, desire additional evidence on the programme's impact in community and healthcare systems before supporting a decision to scale. As such, the primary objective of this study is to investigate the impact of Health-2-Go, as implemented in the Barekese Subdistrict, on the health and well-being of children aged 5 and under.

METHODS

Retrospective study cohort data sources

Retrospective data on (1) births and deaths of children aged 5 and under and (2) health centre visits for children aged 5 and under were collected from a cohort of children exposed and unexposed to Health-2-Go as *proxy measures* of the impact of Health-2-Go on 5 and under mortality, disease severity and health services utilisation.

Specifically, the cohorts were defined as follows*:* (1) the cohort of children *exposed to Health-2-Go* was defined as children born between January 2012 and December 2022 who lived in one of nine communities from the Barekese Subdistrict selected for the study; (2) the comparison cohort of children *unexposed to Health-2-Go* was defined as children born between January 2012 and December 2022 who lived in one of six communities from the Asuofua Subdistrict selected for the study.

Communities were stratified by size (categorised as large or small for eligible communities) and randomly selected until recruitment achieved the required sample size, based on *a priori* calculations indicating that 1198 observations for the intervention and control groups were needed to detect a reduction in under-5 mortality from 47.5 deaths per 1000 live births to fewer than 25 deaths per 1000 live births (β=0.8; α=0.05; design effect=1.07).[26–28] For communities selected, we attempted to exhaustively recruit participants (households were contacted over the course of 2–3 days up to three times). No communities in this study (from either cohort) had a health centre or CHPS located in their immediate community boundary during the time period of our study. Comparison cohort communities were selected based on several criteria. They belong to the Asuofua Subdistrict, which is the neighbouring subdistrict to the Barekese Subdistrict and fall under the same district-level leadership and policy. They have similar proximity to Kumasi, Ghana's second-largest city, and have experienced similar levels of urbanisation to the Health-2-Go communities.

Data on births and deaths for children 5 and under were collected from each community listed above via a verbally administered household census questionnaire using a subset of items from the Demographic and Health Survey.[29] Data on health services utilisation for children 5 and under were collected via a health record extraction from patient files at two subdistrict health centres, one selected for each cohort. These health centres are where we would expect children from our cohorts to visit if they sought access to full primary care services.

Dependent variables

Data collected from the household census questionnaire and clinical records were analysed separately. For our all-cause mortality analysis, we defined our dependent variable (child survival) as the number of years a child was observed alive in our study from 1 January 2012, or birth, to one of the following: death, their sixth birthday, their move to a community outside our study, or 31 December 2022—whichever came first. Because of the potential for recall bias introduced at data collection (*see Limitations*), all births, moves and deaths were assigned to take place on 1 July of the relevant year. This approach allowed us to standardise the timing of these events across the dataset, minimising the impact of any uncertainties in the reported data.

For our health services utilisation analysis, we defined our dependent variable as all documented outpatient department (OPD) visits resulting in a malaria diagnosis from two subdistrict health centres (one selected for each cohort) for all children younger than age 6 years. The observation period for each health centre was all days between 1 January 2012 and 31 December 2022, for which the physical OPD Consult Book could be located. We collapsed our data into week-year summaries, by health centre, of the total number of visits resulting in a malaria diagnosis for all children younger than age six.

Independent variables

Health-2-Go was fully operational in the Barekese Subdistrict beginning in 2019. For our child mortality analysis, exposure to Health-2-Go was defined as the proportion of person-years ('exposure proportion') a child was living in a community with access to a Health-2-Go CBA, from 1 January 2012, or birth, to one of the following: death, their sixth birthday, their move to a community outside our study, or 31 December 2022—whichever came first. For example, for a child who was born before 2019 in a community with a Health-2-Go CBA, we divided the number of years the child was observed after 1 January 2019 by the total number of years the child was observed in our study. An exposure of '0' indicates that the child never had exposure to Health-2-Go, and an exposure of '1' indicates that a child always had exposure to Health-2-Go. This definition of Health-2-Go exposure ensures that our child mortality analysis addresses *immortal time bias,* which is critical for accurately estimating the programme's impact on child mortality.[30] By operationalising exposure to Health-2-Go as a proportion of time at risk rather than a binary classification variable, we accounted for varying levels of exposure among children living in communities that gained access to the programme in 2019. This approach provided a more precise estimation of the programme's effect, capturing the nuanced impacts of different exposure durations.

For our health services utilisation analysis, we assigned Health-2-Go exposure at the health centre level and by time period. We considered all visits to the health centre located in the subdistrict implementing Health-2-Go to be exposed to the intervention, and all visits to the health centre located in the subdistrict without Health-2-Go to have no exposure to the intervention. Additionally, we considered all visits before 1 January 2019 as preimplementation of Health-2-Go' and all visits from 1 January 2019 onward as postimplementation of Health-2-Go. Only visits that took place in the health centre located in the Health-2-Go subdistrict after 1 January 2019 were considered exposed to the intervention. A '0' would indicate that the week-year was not exposed to Health-2-Go (either because the health centre was not in the subdistrict implementing Health-2-Go and/or the time period was before the implementation of Health-2-Go) and '1' would indicate that the week-year was exposed to Health-2-Go.

Statistical analysis

All statistical analyses were planned *a priori* (unless otherwise indicated) and conducted using Stata statistical software (*StataCorp 2007. Stata Statistical Software. Release* IC 15.1 *StataCorp LP, College Station Texas, USA)*. The independent and dependent variables were selected *a priori* based on the fundamental approach used by Health-2-Go and tested in this research. Additional covariates were likewise selected *a priori*, except for the *hard-to-reach* indicator. Based on observations during data collection, we added the hard-to-reach indicator to better account for differences (other than the primary independent variable) that existed between the intervention and comparison communities. We acknowledge that other factors not included in this study may contribute to a reduction in child mortality and/or healthcare utilisation.

A Cox proportional hazards regression model was conducted to estimate the association between the proportion of exposure to Health-2-Go and the number of years a child was observed alive in our study. The event-to-time (failure) was defined as death, while children who moved or aged beyond 60 months were censored. Covariates were included and determined *a priori*, based on various individual and contextual factors, such as caregiver attributes (*marital status, education level and religious affiliation*). Additionally, an indicator ('hard-to-reach indicator') for residing in a community with access limited to an unmaintained dirt road was added after data collection. The log-likelihood and likelihood ratio (LR) χ^2 tests were used to understand the best fit of the models.

A negative binomial regression analysis was conducted to examine the number of clinic visits resulting in a malaria diagnosis during a given week-year by the health centre. A series of difference-in-difference analyses were run to test the association of selected variables, such as the total number of visits resulting in a malaria diagnosis ('weekly total malaria dx'), with our independent variable, the interaction of health centre with time period relative to Health-2-Go implementation ('post*clinic'). Additional explanatory variables, identified *a priori*, included various individual and contextual factors, such as the mean age of patients seen in a given week ('average patient age'), the total number of patients by age group seen in a given week ('total patient age 0', 'total patient age 1', 'total patient age 2', 'total patient age 3', 'total patient age 4' and 'total patient age 5'), the proportion of male patients in a given week ('total male') and the proportion of patients enrolled in the National Health Insurance Scheme in a given week ('total insurance'). The LR χ^2 test was then performed to assess the fit of the negative binomial distribution and the log likelihood ratio to understand the best fit among our models.

RESULTS

We collected data on a total of 2530 children through our verbal household census questionnaire; cohort 1 (*exposed* to Health-2-Go) includes data on 1202 children from nine communities, and cohort 2 (*unexposed* to Health-2-Go) includes data on 1328 children from six communities. Of these children, we identified 110 deaths that took place during the time period defined by our study.

We collected 72 week-years of visit data for children aged 5 and under from the subdistrict health centre *exposed* to Health-2-Go and 69 week-years of visit data for children aged 5 and under from the subdistrict health centre *without exposure* to Health-2-Go through our health records extraction. Of these 141 week-years, 48 were overlapping, where information was collected for the same week-year from both clinics. We limited our regression models to only include these overlapping week-years (where both clinics provided data). Demographic information about the sample is presented in table 1.

All-cause child mortality

The results from the all-cause mortality analysis are reported in table 2. In the initial model (Model 1.1), which included only the independent variable proportion of exposure to Health-2-Go, we found a significant association with the hazard of death. The model yielded a HR of 0.387 (*p=0.022; 95% CI 0.171, 0.874*), indicating that higher exposure to Health-2-Go was associated with a reduced risk of death. Specifically, for every unit increase in the proportion of exposure (from 0 to 1), there was a statistically significant 61.3% reduction in the rate of death. The log likelihood of the model was −523.181 and the LR χ^2 test was significant (*Chi2=6.08, p=0.014*), suggesting a good model fit.

We extended the model (Model 1.2) to include an indicator variable, determined *a priori*, for residing in a particularly hard-to-reach community (defined as communities limited to an unmaintained dirt road, making them particularly hard-to-reach, ie, frequent flooding of the access road). In this model, the hard-to-reach indicator was not statistically significant. The proportion of exposure to Health-2-Go had an HR of 0.365 (*p=0.024; 95% CI 0.153, 0.874*), reinforcing the protective effect of Health-2-Go exposure. The 'hard-to-reach indicator' had an HR of 1.161 (*p=0.695; 95% CI 0.550, 2.450*). The log likelihood of this model improved slightly to −523.106, with an LR χ^2 test of 6.23 (*p=0.044*), demonstrating a similar model fit as compared with the initial model.

Finally, the model was extended (Model 1.3) to include additional potential explanatory variables (caregiver attributes) to determine their impact on the model. In this comprehensive model, the proportion of exposure to Health-2-Go remained significantly associated with a reduced hazard of death, with an HR of 0.323 (*p=0.015; 95% CI 0.130, 0.803*). The hard-to-reach indicator remained statistically non-significant, with an HR of 1.188 (*p=0.660; 95% CI 0.551, 2.564*) controlling for all other covariates. Notably, the caregiver attribute of 'divorced' was statistically significant with an HR of 3.585 (*p=0.008; 95% CI 1.402, 9.164*), indicating a higher hazard of death associated with children of divorced caregivers. Other

Table 1 Descriptive statistics of the analysis sample

Child characteristics (n=*2530*)		**Health-2-Go N (%)**	**Comparison N (%)**
Birth year	*2012*	56	49
	2013	87	100
	2014	96	116
	2015	103	121
	2016	117	143
	2017	123	109
	2018	126	141
	2019	152	139
	2020	107	140
	2021	118	151
	2022	117	119
Death year	*2012*	4	1
	2013	3	2
	2014	2	2
	2015	1	2
	2016	6	3
	2017	9	5
	2018	6	5
	2019	6	7
	2020	8	11
	2021	6	4
	2022	8	9
Gender	*Male*	591 *(49.25%)*	661 *(49.92%)*
Clinic visit characteristics by week-year *(n=141)*		**Health-2-Go** *Mean Min Max*	**Comparison** Mean *Min Max*
Total weeks of healthcare encounters *(children 5 and under)*		n=72	n=69
Total number of weekly clinic visits *(children 5 and under)*		3.6 (1, 13)	14.5 (2, 26)
Patients registered to the National Health Insurance Scheme *(children 5 and under)*		3.18 (0, 12)	13.23 (1, 26)

variables did not statistically contribute to the model performance. The log-likelihood of this model was −500.403 with an LR χ^2 test of 20.62 (*p=0.024*), suggesting that Model 1.3 provides the best fit of our three models.

Healthcare utilisation

The results from the healthcare utilisation analysis are reported in table 3. In the initial model (Model 2.1), the 'post*clinic' variable had a coefficient of −1.436 (*95% CI −2.62 to −0.25; p=0.017*) on an outcome variable of the total number of <u>all</u> malaria diagnoses, indicating that the implementation of Health-2-Go was associated with a significant reduction in the number of visits resulting in malaria diagnoses. The incidence rate ratio (IRR) for the 'post*clinic' variable was calculated as 0.24 (*95% CI 0.07, 0.78*), suggesting a 76% reduction in expected weekly malaria cases among patients 5 and under at the clinic exposed to Health-2-Go postimplementation. The same model was run (Model 2.2) to include an additional potential explanatory variable (total number of diarrhoea diagnoses), but it did not meaningfully contribute to the model. Our independent variable 'post*clinic' remained stable, with a coefficient of −1.440 (*p=0.018; 95% CI −2.63–0.25*) and IRR of 0.24 (*95% CI 0.07, 0.78*).

Further analysis was conducted for uncomplicated malaria diagnoses (Model 2.3), which yielded similar results. The 'post*clinic' variable remained significant (*coefficient=−1.764; 95% CI −3.33 to −0.20; p=0.027*), reinforcing the conclusion that Health-2-Go implementation was associated with a reduction in the number of malaria cases seen at the health centre. The IRR for the 'post*clinic' variable was calculated as 0.17 (*95% CI 0.04, 0.82*), suggesting an 83% reduction in expected weekly uncomplicated malaria cases among patients 5 and under at the clinic exposed to Health-2-Go postimplementation.

Table 2 Coefficients from estimated Cox proportional hazards regression models

Variable	Model 1.1 Proportional hazards model *Log likelihood=−523.18078* *LR χ^2=6.08 (p=0.0137)*			Model 1.2 Proportional hazards model *Log likelihood=−523.10617* *LR χ^2=6.23 (p=0.0444)*			Model 1.3 Proportional hazards model *Log likelihood=−500.40251* *LR χ^2=20.62 (p=0.024)*		
		95% CI (HR)			*95% CI (HR)*			*95% CI (HR)*	
	HR	*Lower bound*	*Upper bound*	HR	*Lower bound*	*Upper bound*	HR	*Lower bound*	*Upper bound*
Exposure proportion	*0.387	0.171	0.874	*0.365	0.153	0.874	*0.323	0.130	0.803
Hard to reach indicator				1.161	0.550	2.450	1.188	0.551	2.564
Caregiver marital status									
Never married							1.242	0.568	2.716
Consensual union							1.625	0.857	3.08
Married							–	–	–
Separated							0.000	.	.
Divorced							*3.585	1.402	9.164
Widowed							2.260	0.939	5.439
Caregiver religious affiliation									
Christian							–	–	–
Islam							0.937	0.443	1.982
Traditional							0.000	.	.
No religious affiliation							0.000	.	.
Other							0.000	.	.
Caregiver highest level of schooling									
No schooling							–	–	–
Basic schooling (eg, primary school)							0.882	0.467	1.666
Secondary/technical schooling (eg, high school)							0.615	0.245	1.545
Higher schooling (eg, post high school)							0.479	0.061	3.758

*Indicates a p value ≤0.05.

Table 3 Coefficients from estimated negative binomial regression models

Variable	Model 2.1: weekly number of all malaria Dx *Log likelihood=−72.064305* *LR χ^2=89.71 (p=0.0000)* *Pseudo R^2=0.3836*				Model 2.2: weekly number of all malaria Dx *Log likelihood=−72.062899* *LR χ^2=89.71 (p=0.0000)* *Pseudo R^2=0.3836*				Model 2.3: weekly number of uncomplicated malaria Dx *Log likelihood=−63.974697* *LR χ^2=87.20 (p=0.0000)* *Pseudo R^2=0.4053*				Model 2.4: weekly number of complicated malaria Dx *Log likelihood=−51.509311* *LR χ^2=30.16 (p=0.0026)* *Pseudo R^2=0.2265*			
	coefficient	**IRR**	**95% CI (IRR)**		**coefficient**	**IRR**	**95% CI (IRR)**		**coefficient**	**IRR**	**95% CI (IRR)**		**coefficient**	**IRR**	**95% CI (IRR)**	
			Lower bound	Upper bound			Lower bound	Upper bound			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Clinic	0.338	1.40	0.66	2.99	0.352	1.42	0.57	3.55	−0.133	0.88	0.34	2.26	1.544	4.68	0.82	26.62
Post	0.144	1.16	0.61	2.18	0.149	1.16	0.60	2.24	0.103	1.11	0.55	2.25	0.209	1.23	0.25	6.06
Post*clinic	*−1.436	0.24	0.07	0.78	*−1.440	0.24	0.07	0.78	*−1.764	0.17	0.04	0.82	0.834	2.30	0.27	19.92
Average patient age	0.298	1.35	0.89	2.05	0.299	1.35	0.89	2.05	0.379	1.46	0.80	2.67	0.182	1.20	0.79	1.82
Total patients age 0	0.107	1.11	0.93	1.33	0.108	1.11	0.93	1.33	0.144	1.16	0.95	1.41	−0.274	0.76	0.43	1.33
Total patients age 1	*0.385	1.47	1.25	1.73	*0.384	1.47	1.25	1.73	*0.342	1.41	1.17	1.69	0.365	1.44	0.94	2.21
Total patients age 2	0.175	1.19	0.92	1.55	0.173	1.19	0.91	1.55	0.141	1.15	0.86	1.54	0.242	1.27	0.73	2.21
Total patients age 3	*0.181	1.20	1.04	1.38	*0.180	1.20	1.04	1.38	0.132	1.14	0.98	1.32	0.354	1.42	0.81	2.51
Total patients age 4	*0.397	1.49	1.14	1.93	*0.397	1.49	1.14	1.93	*0.348	1.42	1.05	1.92	−0.040	0.96	0.46	2.00
Total patients age 5	0.273	1.31	0.99	1.74	0.269	1.31	0.95	1.80	0.252	1.29	0.94	1.76	−0.606	0.55	0.25	1.19
Total male	−0.070	0.93	0.84	1.04	−0.069	0.93	0.83	1.04	−0.015	0.99	0.88	1.11	−0.170	0.84	0.63	1.13
Total insured	−0.082	0.92	0.80	1.07	−0.082	0.92	0.80	1.07	−0.094	0.91	0.77	1.07	0.110	1.12	0.79	1.57
Total diarrhoea dx					0.007	1.01	0.78	1.30								
Constant	−0.714	0.49	0.18	1.36	−0.731	0.48	0.14	1.60	−0.943	0.39	0.11	1.40	*−2.865	0.06	0.01	0.52

*Indicates a p value ≤0.05.

For an analysis looking at severe malaria diagnoses as the dependent variable (Model 2.4), however, the 'post clinic' variable was not statistically significant (*coefficient=0.834; 95% CI −1.32, 2.99; p=0.238*), suggesting no significant association between Health-2-Go implementation and the number of severe malaria cases 5 and under at the clinic exposed to Health-2-Go postimplementation.

The fit of the negative binomial models was tested using the LR χ^2 test, which confirmed that the negative binomial distribution was more appropriate for the data compared with the Poisson distribution. The LR χ^2 test indicated a good fit for the negative binomial model across different specifications. The models consistently showed significant associations between the independent variables (postimplementation exposure to Health-2-Go) and the dependent variables, except when testing the dependent variable of 'weekly number of complicated Malaria diagnoses' (Model 2.4).

DISCUSSION

The findings underscore the effectiveness of the Health-2-Go programme in impacting the health of children aged 5 and under by extending primary healthcare services closer to underserved communities through CBAs trained in iCCM guidelines. We used data sources that were independent from Health-2-Go programme data to understand the impact of the iCCM strategy, as implemented by Health-2-Go, on key indicators of child health and well-being. We found exposure to the Health-2-Go programme to be associated with a reduction in clinic visits for uncomplicated malaria among children 5 and under (*IRR=0.17; p=0.027; 95% CI 0.04, 0.82*) coupled with a decline in all-cause mortality for this same population (*HR=0.323; p=0.015; 95% CI 0.130, 0.803*). These findings indicate that Health-2-Go is successfully shifting the burden of care from overstretched health facilities to the community level, while improving the health and well-being of its focal population of children 5 and under.

Research on the impact of other iCCM-based programmes has been mixed. Regarding the iCCM programme's impact on child mortality, studies have reported considerable variation in terms of both the magnitude and statistical significance of findings. For instance, the review of iCCM programmes in Burkina Faso, Cameroon, Ghana, Sierra Leone, Ethiopia, Uganda and Zambia by Amouzou *et al* reports a 'higher decline' in under-5 mortality for children exposed to iCCM programmes; however, only one of those studies reported findings that were statistically significant;[31] the study by Chinbuah *et al*[32] reported a statistically significant 44% reduction in all-cause mortality for children under 5 exposed to full iCCM programming.[32] Prosnitz *et al*[33] report an average estimated 10% decline in under-5 mortality, based on the Lives Saved Tool computer modelling software, associated with exposure to iCCM programming across six Rapid Access Expansion (RAcE) sites located in the Democratic Republic of the Congo, Malawi, Mozambique, Niger and Nigeria.[33] Our study finding of a statistically significant 67.7% reduction (*HR=0.323; p=0.015; 95% CI 0.130, 0.803*) in the risk of death for children 5 and under exposed to the Health-2-Go programme is consistent with the broader literature in terms of the direction of impact on mortality; however, our finding suggests a greater magnitude of this impact than has been reported elsewhere. The success of the Health-2-Go programme might be attributable to several unique and particularly well-implemented components that set it apart from other iCCM initiatives. One hypothesis is that the programme's codesign approach, which involved local academic, clinical and community partners from the outset, has created a highly relevant and context-sensitive intervention. Another potential factor is the strong emphasis that Health-2-Go places on high-quality equipment and supplies, which likely enhances CBA's capacity to deliver reliable, high-quality care; ongoing training to ensure sustained competency of CBAs and an effective, supportive supervisory structure that clearly integrates with the formal clinical system.

Current literature also reports a range of findings regarding the impact of iCCM programmes on clinic utilisation for children aged 5 and under. A study by Isiguzo *et al*[34] on a pioneering iCCM initiative in Nigeria, facilitated by the WHO RAcE, reported a decrease in the number of caregivers selecting to seek care from health centres from 34% (baseline survey) to 24.8% (endline survey).[34] In contrast, Zalisk *et al*[35] reported that for a mature iCCM programme in Malawi (again, part of the WHO RAcE), there was a significant decline in caregivers' perceptions of the iCCM-trained community agent as a trusted healthcare provider (82.3% baseline, 70.3% endline) and as a convenient source of care (59.6% baseline, 57.6% endline).[35] Yansaneh *et al*[36] report a statistically significant 79% reduction in health facility treatments for malaria among children with access to community health volunteers in two underserved districts of Sierra Leone,[36] which aligns with our finding of a statistically significant 83% reduction (*IRR=0.17; p=0.027; 95% CI 0.04, 0.82*) in unnecessary clinic visits for uncomplicated malaria among children with access to 'Health-2-Go'.

The variations in findings reported in the literature for both mortality and clinic utilisation highlight the importance of having an effective implementation model to deliver the iCCM strategy. While the iCCM is built on sound evidence, without an effective and standardised implementation package, the results and programme impact may vary.[37] Further research that clarifies the core components of the Health-2-Go intervention and its implementation would complement the findings reported in this study and provide valuable insights for adapting and scaling the programme in different settings.

Limitations and practical insights

We acknowledge that this study faced inherent limitations typical of retrospective research and working in real-world, developing settings, such as the potential for recall bias and incomplete records. For example, some participants found it challenging to remember the exact dates of birth and death events from the 10year- period defined by our study. Although we asked to see formal records, such as birth or death certificates, data on the time of an event (ie, birth, death) was often limited to only a known month and/or year. Additionally, our ability to query patient folders was limited by the paper-based record-keeping system, restricting our sample to individuals for whom we could locate the physical patient folder and who were recorded as receiving OPD treatment on dates for which we could locate the OPD Consultation Records book. However, the study methods and analysis were thoughtfully designed to account for these challenges to the extent possible. Additionally, the study design benefited from the guidance of local researchers on our team (especially SM, MS and SCA) who have experience with this approach to data collection and analysis, ensuring that the conclusions we derived reflected the realities of the study setting. This study demonstrates the Health-2-Go programme's potential benefits and lays the groundwork for additional studies. Future research with prospective designs could provide further validation and help to extend our findings, offering a clearer understanding of the Health-2-Go programme's long-term impact on child health outcomes in rural Ghana.

Our experience highlighted the necessity of conducting house-to-house data collection to capture an accurate census, despite the significant effort required. In these areas, the formal documentation of vital events such as births and deaths is less common, often due to cultural practices that prioritise oral history and communal knowledge over formalised records. Previous studies have noted similar challenges in rural settings, where significant events are recorded based on memorable communal occurrences rather than specific dates.[38–40] Therefore, this research benefited from the comprehensive data collection methods to ensure the best accuracy possible and capture the full scope of vital events in these settings.

Additionally, we propose that health facilities serving rural and hard-to-reach communities in Ghana could benefit from summarising their data at the community level rather than solely at the clinic level. This practice could enhance their understanding of changes within the communities they serve, allowing them to more effectively prioritise community interventions by better understanding their impact on clinic use and health outcomes. While clinics in Ghana are meticulous in their record-keeping, slight adjustments in data aggregation and storage practices could significantly improve the ability to conduct effective research and enhance health outcomes. This recommendation aims to support and optimise the commendable efforts of Ghana Health Service by suggesting practical enhancements that could lead to substantial benefits in healthcare delivery and research.

Conclusion

In conclusion, the Health-2-Go programme demonstrates significant potential in reducing all-cause child mortality and improving access to essential healthcare services in rural Ghana. By evaluating healthcare utilisation alongside mortality, our study provides robust evidence supporting the Health-2-Go programme effectiveness. These findings support scaling the Health-2-Go programme to more communities, with additional research needed to substantiate and refine its implementation.

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Acknowledgements We would like to thank the entire Health-2-Go team for their support in this research, as well as for their persistent and commendable efforts to improve child health outcomes in rural Ghana through expanded access to basic primary care. A special thank you to the guidance from Health-2-Go leadership, including Professor Stephen C. Alder, Mr Rick Haskins, Dr Stephen Manortey, Dr Gloria Quansah Asare and Dr Chief Nat, as well as to individuals from the 'Health-2-Go' operational team, including Mr Gideon Kwarteng Acheampong, Ms Moselle-Margaret Anum-Brown, Ms Cassandra Cowdell, Dr Jeanette Nelson and Ms Stephanie Duston. We would like to acknowledge and extend our sincere appreciation to the team involved with primary data collection. From Ensign Global College, thank you to Mr Carl Thompson Kumador, Ms Moselle-Margaret Anum-Brown, Mr Philip Owusu Antwi and Mr Ernest Amanor. From the Atwima Nwabiagya North District, thank you to District Director Eric Sarpong, Head of Barekese Center Alhaji Mohammed Shaibu Bansi and Asuofua Polyclinic Administrator Nsimbeh Kwaku Benson. Thank you to the health records staff from the Asuofua Polyclinic: Ama Konadu Bempah, Evans Koranteng and Mavis Afari. A huge thank you to our incredible team of local research assistants: Michael M. Arthur, Nelly Gyamfi, Adjapong Stephen, Denicia Attiah, Elizabeth Konadu, Baba Moari Latif, Juliet Owusu Amankwa, Mary Agyei, Evans Ocran and Eric Osei.And lastly, but not least, the authors would like to recognise the community members—especially the mothers—and all local health personnel of the Barekese subdistrict in the Atwima Nwabiagya North District of the Ashanti Region of Ghana for their relentless dedication to securing a healthier future for their children.

Contributors Conceptualisation: IG, SM, KHL, LF, AJM and SCA. Methodology: IG, SM, MS and SCA. Data collection: IG, SM, MS, M-MA-B, POA and SCA. Data analysis and interpretation: IG, SM, KHL and SCA. Writing—original draft: IG. Writing—review and editing: IG, SM, KHL, LF, AJM, MS, M-MA-B, POA and SCA. Guarantor: IG is the guarantor of this manuscript and takes full responsibility for the integrity of the work, including the data and analysis.

Funding This research was supported by the Cast-A-Pebble charitable foundation, which funded primary data collection, including compensation for local research assistants, procurement of locally sourced supplies, meals, and transportation, and researcher accommodation.

Competing interests None declared.

Patient and public involvement The Barekese Sub-District communities were involved in the design and implementation of Health-2-Go, the focal intervention of this study. In addition to the formal ethical approvals secured for this study, the authors sought and obtained permission from local traditional and civic leadership before engaging with community members to ensure that our activities were culturally respectful and accepted. Findings from this study have been disseminated to the Health-2-Go leadership team and will be communicated to the full operational team (including all Community-Based Agents) through existing communication channels established by Health-2-Go. Additionally, findings are being prepared for sharing at the local level where the research took place, at the regional level with engaged regional health partners, and at the national level –

including being part of a newly developed MOU between Ensign Global University (which hosts the Heatlh-2-Go program), Ghana Ministry of Health, and Ghana Health Service.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. Prior to any data collection, the study team received ethical approval from the Ensign Global College Institutional Review Board (IRB Reference #: ENSIGN/IRB/EL/SN-02), the University of North Carolina at Chapel Hill Institutional Review Board (IRB Reference #: 23-0599) and the Ghana Health Services Ethical Review Committee (ERC Reference #: GHS-ERC 021/05/23). Administrative approvals were obtained from all participating health centres, and informed consent was secured from all respondents prior to participation in the study. Respondents involved in the verbal census were duly informed about the study's purpose, and individual consent was sought before answering the questionnaire.Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

Author note The reflexivity statement for this paper is linked as an online supplemental file 1.

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