

# BMJ Open Eight years into the horizon of aspirational maternal and newborn health pledges: a nationwide cross-sectional exploration of the Burundian EmONC network capacity and budget deficits

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## ABSTRACT

**Objective** The Burundian emergency obstetric and neonatal care (EmONC) programme, which was initiated in 2017 and supported by a specific policy, does not appear to reverse maternal and newborn mortality trends. Our study examined the capacity challenges facing participating EmONC facilities and developed alternative investment proposals to improve their readiness paying particular attention to EmONC professionals, physical infrastructure, and capital equipment.

**Design** Cross-sectional study.

**Setting** Burundian EmONC facilities (n=112).

**Participants** We examined EmONC policy documents, consulted 12 maternal and newborn health experts and 23 stakeholders and policymakers, surveyed all EmONC facilities (n=112), and collected cost data from the Ministry of Health and local suppliers in Burundi. We developed three context-specific EmONC resource benchmark standards by facility type; the Burundian policy norms and the expert minimum and maximum suggested thresholds; and used these alternatives to estimate EmONC resource gaps. We forecasted three corresponding budget estimates needed to address prevailing deficits taking a government perspective for a 5-year EmONC investment strategy. Additionally, we explored relationships between EmONC professionals and selected measures of service delivery using bivariate analyses and graphically.

**Results** The lowest EmONC resource benchmark revealed that 95% of basic EmONC and all comprehensive EmONC facilities lack corresponding sets of human resources and 90% of all facilities need additional physical infrastructure and capital equipment. Assessed against the highest benchmark which proposes the most progressive set of standards for the prevailing workloads, Burundi would require 162 more medical doctors, 1005 midwives and nurses, 132 delivery rooms, 191 delivery tables, 678 and 156 maternity and newborn care beds, and 395 incubators amounting to US\$32.9 million additional budget for 5 years.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study used primary data and was supported by Burundian policy makers and stakeholders including major partners who support the maternal and newborn health programme.
- ⇒ The study included all emergency obstetric and neonatal care (EmONC) facilities to ensure that the results provide a comprehensive preview of the entire Burundian EmONC system to aid budget planning and resources allocation.
- ⇒ The study did not specifically address equity as we were limited in examining the supply of maternity and EmONC services and not potential demand and we have no information on wealth distribution across the populations accessing care.
- ⇒ We recognise that resources itemisation and quantification and the cost allocation are prone to endogenous uncertainty, and it is possible that we failed to account for some non-capital but useful EmONC resources during the identification and quantification of various EmONC resources summarised in online supplemental material 2.
- ⇒ The methodological approach of total budget forecasting did not account for possible cost differences based on geographic locations and urbanicity of health facilities.

**Conclusion** We demonstrated that Burundian EmONC facilities face enormous capacity challenges equivalent to US\$32.9 million funding gap for 5 years; averagely approximating to 5.96% total health budget increase annually.

## INTRODUCTION

Despite political resolve,<sup>1</sup> Burundi continues to grapple with one of the world's highest

maternal and newborn death rates<sup>2–4</sup> even though maternal mortality declined by 43% over the past 20 years from 874 (663–1134) maternal deaths per 100 000 live births in 2000 to 494 (353–694) deaths in 2020.<sup>5</sup> Indeed, two Burundian women out of 100 continue to die of an obstetric complication particularly haemorrhage, infections, eclampsia or unsafe abortion.<sup>6</sup> To accelerate progress to meet the Sustainable Development Goals (SDGs) agenda, Burundi pledged to reduce maternal mortality from 568 deaths per 100 000 live births in 2015 to below 140 deaths per 100 000 live births and further halve neonatal mortality from 23 to less than 12 deaths per 1000 live births in 2030.<sup>7,8</sup>

Burundi began efforts to accelerate progress towards achieving maternal and newborn survival through investments in obstetric care particularly for emergency complications following the 2009 subregional workshop on maternal and newborn health (MNH) in francophone Africa.<sup>9</sup> Early initiatives included an emergency obstetric and neonatal care (EmONC) needs assessments<sup>10–13</sup> and health facility mapping and capacity evaluations conducted in 2010.<sup>14</sup> In 2017, the country formed the ‘maternity network’ comprising 53 hospitals and 59 primary health facilities designated as comprehensive and basic EmONC facilities (CEmONC and BEmONC), respectively. They include 82 (73%) public and 30 (27%) religious and private facilities and are supported by a specific policy that defines maternal and neonatal health goals; proposing how these facilities should be strengthened with appropriate resources to maximise their readiness to provide quality care for emergency obstetric and newborn complications.<sup>15</sup>

The Burundian EmONC programme is principally supported by the United Nations Population Fund (UNFPA), WHO, Japan International Cooperation Agency (JICA), Pathfinder, and various local research and service delivery institutions.<sup>16</sup> With 112 EmONC facilities for a country of 27 834 km<sup>2</sup> with approximately 12 million population, Burundi surpassed the WHO recommendation of one CEmONC and four BEmONC facilities per 500 000 population.<sup>17,18</sup> In many health districts, more than 97% of the population can reach an EmONC facility within 2 hours and user fees for pregnant women and children under-five were removed in 2006.<sup>19</sup> These EmONC facilities are reported to perform a third of all normal facility-based deliveries and manage nearly two-thirds of all obstetric complications.<sup>15,16</sup>

Reduction of maternal and newborn mortality using the EmONC model of care requires that quality care is delivered. The current WHO quality of care framework is based on eight domains that encompass the structure and process of care at health facility level.<sup>20,21</sup> Facility structure comprises essential resources such as physical infrastructure, maternity and neonatology equipment, essential medicines and supplies, and human resources.<sup>20,22,23</sup> Appropriate resources (structure) supporting well delivered care (process) should result in better health outcomes.

Given continued high maternal and newborn mortality, we conducted a comprehensive evaluation of the challenges currently facing Burundian EmONC facilities to identify needs for further improvement and investment.<sup>24</sup> We specifically examined the availability and functionality of EmONC resources, gauging them against expected requirements and estimated key resource deficits. We used cost data to forecast government budget requirements to close identified gaps paying particular attention to human resources, physical infrastructure, and capital equipment.

## METHODS

### Agreeing standards for EmONC resources

First, the Ministry of Health (MoH) formed a study stakeholder committee comprising 23 members from policymakers (eg, MoH cabinet, health programmes), researchers (eg, University of Burundi), development partners (eg, WHO, UNFPA, UNICEF and JICA), implementers (eg, Association Burundaise pour le Bien être Familial) and medical professional associations (eg, Burundian association of gynaecology-obstetricians, Burundian association of neonatologists) (online supplemental material 1). Second, to identify important EmONC resources, we reviewed guidelines and policies and examined the literature<sup>25–30</sup> and health policy documents to extract Burundi’s normative resource requirements<sup>1,16</sup> (online supplemental material 2), and supplemented these findings with a targeted rapid expert survey of 12 MNH experts comprising clinicians, researchers, donors and policymakers. Proposed resource criteria were discussed with stakeholders who ‘sense-checked’ and refined resource standards that seem reasonable and feasible for Burundi.<sup>31</sup> From these discussions, we developed three EmONC resource benchmarks based on the existing Burundian health norms and the expert minimum and maximum scenarios (summarised in table 1). We used these alternative standards to assess EmONC resource gaps and subsequent budget needs.

### Facility survey design, participants and data sources

Our health facility survey tool was adapted from the WHO Service Availability and Readiness Assessment tool,<sup>32</sup> the Quality Evidence for Health System Transformation health facility assessment tool<sup>33</sup> and the Averting Maternal Death and Disability EmONC Needs Assessment toolkit<sup>34</sup> and was further discussed with stakeholders in Burundi. We conducted a cross-sectional survey of all EmONC facilities in Burundi (n=112) interviewing health facility managers and maternity, laboratory, and supply chain head officers to document the availability of delivery care professionals, physical infrastructure, delivery material and equipment, essential EmONC drugs and supplies, laboratory equipment, and maternity amenities. Concerning delivery care professionals particularly, we documented those specifically working in maternity (eg, nurses formally assigned to other facility functions, eg, sick child/adult

**Table 1** Adequate physical and human resource requirements for Burundian EmONC facilities

EmONC physical and human resources	Burundian health norms		Expert suggested requirements	
	BEmONC normative needs	CEmONC normative needs	BEmONC (min, max) needs	CEmONC (min, max) needs
Delivery rooms	1	2	(1, 2)	(2, 3)
Delivery tables	2	4	(2, 3)	(3, 6)
Maternity beds	8	22	(6, 12)	(18, 26)
Operating rooms	NA	Unspecified	NA	(1, 2)
Incubators	Unspecified	Unspecified	(1, 2)	(3, 10)
Neonatal beds	Unspecified	Unspecified	(1, 2)	(2, 4)
OBGYN	NA	Unspecified	NA	(0, 1)
Medical doctors	NA	1	NA	(1, 4)
Midwives	1	4	(1, 3)	(4, 5)
Nurses	2	9	(1, 4)	(4, 12)

**Table 1** summarises the findings of the Burundian EmONC resource requirements development exercise. The table contains the explicit required EmONC resources from the Burundian health norms document and those suggested by MNH experts by facility type. Three EmONC resource benchmarks emerge: (1) the normative requirements, (2) the minimum expert suggested requirements and (3) the maximum expert suggested requirements. 'NA' stands for 'not applicable' and 'unspecified' implies that information is not given in the Burundian EmONC normative document.

bEmONC, basic EmONC; cEmONC, comprehensive EmONC; EmONC, emergency obstetric and neonatal care.

care who might co-cover maternal care were not documented). Routine data for the last 5 years was obtained from the health facility information system and maternity records, and included monthly deliveries, obstetric and newborn complications, and birth outcomes. We trained 54 surveyors formed into 18 teams corresponding to the number of provinces of Burundi. Each team collected data from the province's EmONC facilities over a period of 5 days in July 2022 using a purpose designed digital survey tool (KoboCollect). The principal investigator and an information technology consultant commissioned by WHO monitored data quality daily and communicated with survey teams and all study stakeholders.

### Health facility survey data analysis

We categorised EmONC resources into human resources, physical infrastructure, equipment, laboratory, and ancillary amenities and examined the availability and functionality of these resources against our three benchmarks; the expert minimum, normative and expert maximum requirements by facility type (BEmONC and CEmONC). We identified the proportions of facilities that have a full complement of resources using the three benchmarks and more specific resource deficits. Second, we examined critical needs of human resources, major infrastructure and physical resources at provincial level. We assessed resources alongside workloads using reported number of deliveries in the previous year (ie, in 2021) exploring at individual facility level the relationships between maternal/neonatal staffing (midwives and nurses), annual deliveries and frequency of maternal complications graphically. We used a similar approach to explore the presence of medical doctors in CEmONC facilities. We supplemented this graphical depiction with bivariate

correlation analyses between selected MNH outcomes and EmONC resources. Health outcomes comprised facility-based MMR and facility-based maternal and neonatal mortality rates due to complications; predictors included medical doctors, midwives and nurses, delivery rooms and tables, maternal and newborn care beds, incubators, and functioning intensive care units.

### Cost data analysis and total EmONC programme budget forecast

We collected cost data of different EmONC resources from the MoH departments for human resources, supply chain management and infrastructure using government historical expenditures and payrolls and the 2022–2023 financial planning and budgeting policy document. The purpose of the costing was to forecast the total budget needed to address the prevailing deficits of EmONC resources assessed against our three benchmarks (described in [table 1](#)) taking a government perspective for a 5-year EmONC investment strategy. The 5-year timeframe was chosen to meet the medium-term planning preference for Burundi and corresponds to the remaining timeframe of the SDGs agenda<sup>35</sup> and The Survive, Thrive and Transform agenda<sup>36</sup> from 2025 until 2030. First, we categorised EmONC resources into capital and recurrent resources<sup>37</sup> and examined the quality and the nature of cost data. At this stage, we laid down reasonable assumptions underpinning these costs especially where there are considerable cost uncertainties and used shadow pricing to adjust for market distortions (detailed cost adjustment methods are provided in online supplemental material 3).<sup>38–41</sup> The budgetary costs of health professionals were calculated using monthly financial inclusive government expenditures by type of professional plus the average



costs of onset and biennial EmONC in-service training and 3% annual salary growth as per the Burundian policies. The total government additional budget needs for an EmONC investment was obtained by aggregating annual cost subtotals for 5 years assuming zero discount rate (details are supplemented in online supplemental material 4). To aid proper planning, we assumed that capital costs will wholly be spent in year one (eg, in 2025) and EmONC training done in the first, third and fifth years. Final budgetary estimates were adjusted using the World Bank gross domestic product mean deflator for Burundi over the previous 5 years from 2018 to 2022 (1.043). The yearly and total budgets were converted into US\$ using the average exchange rate for the second quarter of 2023. Forecasts were developed for each set of benchmark standards, existing Burundian policy norms and the expert minimum and maximum suggested requirements, to produce three budget alternatives for policy discussions.

### Patient and public involvement

Patients were not directly involved in this study. We formed a multistakeholder study committee (online supplemental material 1) early in the study design and organised phased meetings to discuss important aspects pertaining to the study: study proposal and ethics, data collection tools, study funding and fieldwork, data quality and findings.

## RESULTS

### Availability and distribution of EmONC physical resources

For clarity and brevity, findings presented in this first section are specific to the assessment of EmONC resource deficits against the expert minimum resources proposal, the least demanding benchmark. Findings are summarised in [table 2](#) and highlight widespread and severe shortages of physical infrastructure and maternity and neonatology equipment in both BEmONC and CEmONC facilities even using this lowest benchmark. Concerning the physical infrastructure and capital equipment, for instance, only one of 59 BEmONC facilities and seven of 53 CEmONC facilities met the overall minimum physical requirements. Specifically, two-thirds of CEmONC facilities require an additional delivery room and in general, maternity and newborn care beds, incubators and resuscitation units are deficient across many CEmONC facilities. More than 90% of BEmONC facilities lack the minimal set of physical resources to provide care for newborns. With the exception of operating theatres which exist in all CEmONC facilities, none of these facilities enjoys a complete set of minimum physical infrastructure and major equipment needed for maternal and newborn care.

Non-capital equipment and laboratory resources such as delivery sets, blood pressure machines, forceps, fetal monitoring apparatus and neonatal resuscitation kits are more commonly available in both types of EmONC facilities. Also, ultrasound and phototherapy machines are available in most CEmONC facilities although the

absence of medical doctors or otherwise qualified human resources may result in ineffective utilisation. Basic laboratory examinations indispensable to diagnose the most frequent maternal and newborn complications or underlying maternal health conditions are individually often available but few BEmONC facilities (12%) can offer all basic laboratory services. More than 95% of CEmONC facilities perform the full set of laboratory checks.

With respect to particular infrastructure and physical resource deficits presented in [table 3](#), operating rooms are recommended in CEmONC facilities exclusively and their deficits are minimal and remain constant irrespective of the policy benchmark. However, Burundi needs considerably more maternity and newborn care beds, incubators and delivery rooms. For instance, compared with the least demanding benchmark (expert minimum standards), EmONC facilities should be expanded with 35 more delivery rooms and equipped with 206 and 65 additional maternity and newborn care beds and 78 more incubators.

The deficits increase as expected in relation to the other two, higher benchmarks. For example, to meet the expert maximum benchmark would require 136 delivery rooms, 191 delivery tables, 678 maternity beds, 156 newborn care beds and 395 incubators. The deficits of infrastructure and major physical resources prevail countrywide without patterns of better or worse off provinces, although those provinces with more EmONC facilities manifest bigger but proportionate deficits.

### Distribution of EmONC human resource deficits

With respect to human resources, we found critical shortages of all types of EmONC professionals against our lowest staffing benchmark. Even achieving this lowest benchmark would make appropriate shift patterns that could sustain quality care impossible to achieve (eg, having only one midwife and one nurse in a BEmONC facility and only one doctor in a CEmONC facility to cover 24 hours for 7 days a week).

Currently we find a professional midwife exists in only 5/59 (9%) BEmONC facilities, though often one generally qualified nurse is present. Only 9/53 (17%) CEmONC facilities have the recommended four midwives available. Importantly, 22 (42%) CEmONC facilities do not have a medical doctor to perform caesarean sections and oversee advanced obstetric and newborn care. On the whole, 95% of BEmONC facilities do not have both one midwife and one nurse and none of the CEmONC hospitals meets the lowest benchmark threshold of one medical doctor, four midwives and four nurses (results are detailed in [table 2](#)).

Concerning human resource deficits and with respect to the lowest benchmark (expert minimum requirements) summarised in [table 3](#), Burundi needs 22 more medical doctors and 277 additional midwives and nurses. The deficit of midwives and nurses doubles when existing Burundian norms are used as the benchmark. Assessed against the expert maximum benchmark (with a total of 4 doctors, 5 midwives and 12 nurses assigned

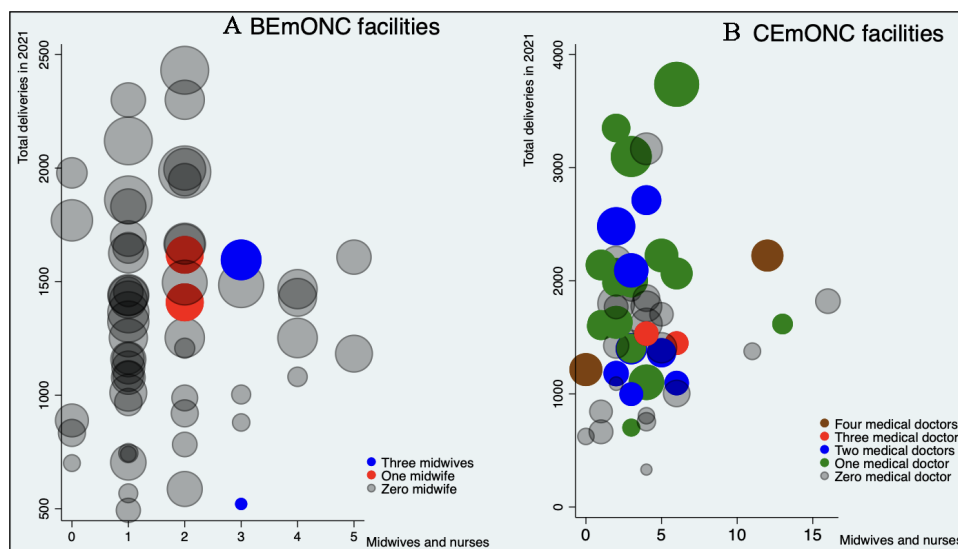
**Table 2** Number of Burundian EmONC facilities meeting the expert minimum resource requirements

	BEmONC (n=59)		CEmONC (n=53)	
	Expert minimum requirements	BEmONC meeting these requirements	Expert minimum requirements	CEmONC meeting these requirements
<b>EmONC professionals</b>	<b>All</b>	<b>3 (5.08)</b>	<b>All</b>	<b>0 (00.00)</b>
Medical doctors	NA	–	One doctor	31 (58.49)
Midwives	One midwife	5 (8.47)	Four midwives	9 (16.98)
Nurses	One nurse	52 (88.14)	Four nurses	4 (7.55)
<b>Physical infrastructure</b>	<b>All</b>	<b>1 (1.69)</b>	<b>All</b>	<b>7 (13.21)</b>
Delivery rooms	One room	59 (100.00)	Two rooms	18 (33.96)
Delivery tables	Two tables	57 (96.61)	Three tables	38 (71.70)
Maternity beds	Six beds	38 (64.41)	18 beds	33 (62.26)
Operating rooms	NA	–	One room	53 (100.00)
Incubators	one incubator	3 (5.08)	three incubators	37 (69.81)
Newborn care beds	One bed	5 (8.47)	Two beds	41 (77.36)
Functioning ICU	NA	–	Available	26 (49.06)
<b>Equipment resources</b>	<b>All</b>	<b>1 (1.69)</b>	<b>All</b>	<b>28 (52.83)</b>
Delivery set	Available	45 (76.27)	Available	53 (100.00)
Adult resuscitation kit	Available	38 (64.41)	Available	51 (96.23)
Adult pulse oximeter	Available	4 (6.78)	Available	51 (96.23)
BP machine	Available	58 (98.31)	Available	53 (100.00)
Forceps or vacuum	Available	46 (77.97)	Available	50 (94.34)
Ultrasound machine	NA	–	Available	52 (98.11)
Foetal monitoring machine	Available	52 (88.14)	Available	51 (96.23)
Neonatal resuscitation kit	Available	51 (86.44)	Available	53 (100.00)
Neonatal pulse oximeter	Available	3 (5.08)	Available	44 (83.02)
Infant weighing scale	Available	58 (98.31)	Available	53 (100.00)
Phototherapy machine	NA	–	Available	40 (75.47)
<b>Laboratory resources</b>	<b>All</b>	<b>7 (11.86)</b>	<b>All</b>	<b>45 (84.91)</b>
Beta hCG	Available	49 (83.05)	Available	50 (94.34)
Blood creatinine	Available	10 (16.95)	Available	53 (100.00)
Proteinuria	Available	38 (64.41)	Available	53 (100.00)
Full blood count	Available	9 (15.25)	Available	52 (98.11)
Blood typing and matching	Available	11 (18.64)	Available	53 (100.00)
Malaria rapid test	Available	57 (96.61)	Available	49 (92.45)
Malaria microscopy	Available	59 (100.00)	Available	53 (100.00)
Blood glucose	Available	53 (89.83)	Available	53 (100.00)
Urine glucose	Available	50 (84.75)	Available	52 (98.11)
<b>Other amenities</b>	<b>All</b>	<b>40 (67.80)</b>	<b>All</b>	<b>47 (88.68)</b>
Electricity	Available	56 (94.92)	Available	53 (100.00)
Water (maternity)	Available	50 (84.75)	Available	53 (100.00)
Public toilet (maternity)	Available	45 (76.27)	Available	49 (92.45)
Ambulance services	Available	56 (94.92)	Available	53 (100.00)

**Table 2** summarises the expert minimum EmONC resources requirements and the number and proportion of facilities meeting these minimum requirements by type of facility. We excluded routine supplies such as essential medicines, transfusion blood, oxygen, clean and sterile gloves, and partographs since they will not account for the additional EmONC budget. NA stands for 'not applicable'. bEmONC, basic EmONC; cEmONC, comprehensive EmONC; EmONC, emergency obstetric and neonatal care.

**Table 3** Distribution of EmONC professional and capital resource deficits by benchmark alternative and province

EmONC professional deficits										Capital EmONC resource deficits										
		Medical doctors			Midwives and nurses			Delivery rooms		Delivery tables		Maternity beds		Theatre rooms		Newborn care beds		ICU		
Province	BE-mONC facilities	Number of deliveries in-year and 2021	Minimum		Burundian		Minimum		Expert		Burundian		Expert		Burundian		Expert		Either maximum scenario	
			Expert maximum	Expert minimum	Expert maximum	Expert minimum	Expert maximum	Expert minimum	Expert maximum	Expert minimum	Expert maximum	Expert minimum	Expert maximum	Expert minimum	Expert maximum	Expert minimum				
Garkuzo	1	2	3551	0	5	8	18	30	1	4	0	2	3	13	25	1	14	1	4	2
Bururi	1	3	6319	0	8	16	32	48	3	7	1	4	10	5	7	1	21	0	1	1
Mwaro	2	2	6349	1	7	14	26	42	2	6	3	5	11	24	34	1	3	18	2	6
Makamba	4	2	6733	2	8	10	22	45	2	8	0	1	9	10	18	4	19	3	9	2
Muramvya	2	2	7223	1	7	13	25	41	2	6	0	2	7	11	21	37	0	3	18	1
Runonge	4	1	8204	0	2	6	15	35	1	6	0	1	14	15	23	42	0	3	13	7
Bujumbura city	6	8735	4	19	11	24	49	0	2	0	0	0	8	0	4	1	6	25	1	5
Karusi	4	2	8743	1	6	9	20	42	1	6	1	2	8	1	7	19	0	3	18	4
Rutana	2	3	8877	2	11	16	32	52	2	7	0	2	9	14	24	38	1	2	22	4
Cibitoke	2	4	9604	3	15	17	38	60	4	10	2	5	14	27	39	57	1	4	32	3
Ruyigi	2	3	9904	2	11	17	34	54	2	6	1	2	6	5	17	35	2	4	26	2
Bujumbura rural	3	10099	0	7	15	33	57	2	8	2	4	4	13	1	5	19	0	6	30	4
Bubanza	3	3	11464	1	10	12	28	46	2	8	1	3	10	16	24	39	0	5	24	5
Kirundo	7	2	11579	0	5	19	36	72	2	10	1	2	11	29	45	76	0	10	24	8
Kayanza	5	3	11963	1	9	22	41	72	3	11	1	4	13	9	15	26	2	5	21	5
Muyinga	6	3	13058	2	11	19	40	76	3	11	1	2	13	11	25	49	0	6	22	8
Gitega	4	6	13349	2	15	38	72	112	1	9	1	2	14	10	28	60	2	3	22	3
Ngozi	6	3	15065	0	6	15	36	72	2	11	2	4	15	15	27	53	1	9	26	8
Total	59	53	170819	22	162	277	572	1005	35	136	17	47	191	206	372	678	15	78	395	65
										</										



**Figure 1** Relationships between EmONC professionals and workloads. Note: bubble sizes correspond to the number of maternal complications. bEmONC, basic EmONC; cEmONC, comprehensive EmONC; EmONC, emergency obstetric and neonatal care.

to a CEmONC facility), the additional needs of EmONC professionals increase to 162 medical doctors and 1000 midwives and nurses. With reference to the latter, the majority of provinces would need more than 10 medical doctors and between 40 and 80 midwives and nurses. Once again, provinces with fewer EmONC facilities have lower but likely proportionate human resource deficits (eg, Cankuzo needs 5 medical doctors and 30 midwives/nurses under the expert maximum benchmark).

### Relationships between EmONC professionals and workloads

Based on the 2021 EmONC report, BEmONC facilities performed between 493 and 2431 (median 1365) deliveries and managed from 77 to 1748 (median 805) maternal complications and 15 to 670 (median 215) newborn complications. CEmONC facilities performed relatively more deliveries and handled more complications; between 331 and 3737 (median 1622) deliveries, 149 and 2385 (median 876) maternal complications and between 29 and 816 (median 247) newborn complications. We expected a positive relationship between EmONC professionals (with midwives and nurses counted together) assigned to EmONC services and the annual number of deliveries, but figure 1 does not support such a relationship. Five BEmONC facilities and two CEmONC facilities were found to have no EmONC specific midwife or nurse.

Figure 1A demonstrates that in some BEmONC facilities, 2000 or more annual deliveries take place in particularly understaffed facilities with fewer than three midwives and nurses combined. Two facilities without either professional dedicated to EmONC services performed more deliveries in 2021 than some facilities staffed with four or five midwives and nurses. In fact, four facilities with ten or more midwives and nurses performed half the number of deliveries compared with many understaffed facilities.

With regard to reported case-mix as expected, facilities performing more deliveries tend to report caring for more women with complications. But this is an inconsistent relationship as is the proportion of women with a reported complication. As noted above higher workloads and thus higher numbers of women with complications are not necessarily receiving care in facilities with higher numbers of staff.

CEmONC facilities show similar patterns seen in figure 1B. In the large majority, there is a major shortage of midwives and nurses. Data show that about 90% of deliveries take place in facilities staffed with fewer than six midwives and nurses and that the number of complications increases with deliveries. Furthermore, only one medical doctor is assigned to delivery care in 18 (34%) CEmONC facilities with annual deliveries in this subset of facilities varying from 702 to 3737. Meanwhile, figure 1B shows that in CEmONC facilities with three or four medical doctors, the annual number of deliveries reported ranges between 1215 and 2223. One CEmONC facility which reportedly performed 624 deliveries in 2021 does not have either EmONC professional and another CEmONC facility has four medical doctors without a midwife or nurse assigned to maternity services.

Finally, results of the bivariate analyses detected interesting but weak and generally non-significant correlations between MNH outcomes and infrastructure and physical EmONC resources. For instance, there are negative but weak or moderate and commonly non-significant relationships (correlation coefficients range between 0.1 and 0.5) between the number of delivery rooms, delivery tables, and that of maternity beds and maternal and neonatal deaths due to complications. Findings are supplemented in online supplemental material 5.

**Table 4** Total government budget needs for a 5-year emergency obstetric and neonatal care (EmONC) investment strategy by benchmark scenario

	Human and capital resources			Other resources	
	Expert minimum	Normative standards	Expert maximum		
<b>Human resources</b>	<b>13 634 945 433.93</b>	<b>26 838 568 556.24</b>	<b>54 090 410 713.60</b>	<b>1 404 314 982.29</b>	<b>Equipment</b>
Medical doctor	1 236 967 112.30	1 236 967 112.30	9 108 576 008.78	9 628 407.08	Delivery set
Midwives and nurses	12 397 978 321.62	25 601 601 443.93	44 981 834 704.81	2 876 017.70	Adult resuscitation kit
<b>Capital resources</b>	<b>9 262 666 548.67</b>	<b>15 072 566 867.26</b>	<b>21 112 620 849.56</b>	<b>1 000 353.98</b>	Neonatal resuscitation kit
Delivery rooms	1 604 734 513.27	1 604 734 513.27	6 235 539 823.01	53 643 982.30	Fetal monitoring machine
Delivery tables	56 450 530.97	156 069 115.04	634 238 318.58	234 805.31	Infant weighing scale
Maternity beds	626 805 132.74	1 131 900 530.97	2 062 980 000.00	53 338 318.58	Ultrasound machine
Operating rooms	–	916 991 150.44	916 991 150.44	88 503 539.82	Phototherapy machine
Incubators	1 028 447 256.64	5 208 162 389.38	5 208 162 389.38	139 271 504.42	Blood pressure machine
Neonatal beds	77 485 752.21	185 965 805.31	185 965 805.31	847 299 823.01	Forceps
Intensive care unit	5 868 743 362.83	5 868 743 362.83	5 868 743 362.83	123 710 442.48	Adult pulse oximeter
				84 807 787.61	Neonatal pulse oximeter
				<b>12 459 742 300.89</b>	<b>Laboratory examinations</b>
				840 297 345.13	Beta hCG
				420 148 672.57	Proteinuria
				1 307 129 203.54	Blood typing and matching
				8 402 973 451.33	Malaria rapid test
				835 629 026.55	Blood glucose
				653 564 601.77	Urine glucose
<b>Total budget</b>	<b>22 897 611 982.60</b>	<b>41 911 135 423.49</b>	<b>75 203 031 563.15</b>	<b>13 864 057 283.18</b>	
Budget BIF	36 761 669 265.78	55 775 192 706.67	89 067 088 846.33		
<b>Budget US\$*</b>	<b>13 555 935.44</b>	<b>20 567 208.36</b>	<b>32 843 658.37</b>		

Table 4 summarises the total government budget for a 5-year EmONC investment strategy by benchmark scenario. Supplies, maintenance and overheads costs are routine expenditures and are explicitly excluded from the total additional EmONC investment budget needs. However, these costs are important as the government must bear in mind that EmONC facilities will continue to require these investments regularly commensurate with inflation and growth in demand for delivery services. \*1 BIF=US\$0.00035361709.

### EmONC programme budget estimates

Findings of the EmONC programme budget forecast are summarised in table 4. Overall, Burundi needs an estimated US\$13.6million for a 5-year EmONC investment strategy (average annual 2.46% increase of the total health budget) to meet standards for the lowest benchmark (expert minimum requirements) excluding the budget for routine supplies (eg, drugs, transfusion blood, sterile and clean gloves, partographs), maintenance (eg, buildings, equipment, ambulance) and overheads (eg, other operational costs). The corresponding budgets required to address EmONC resource deficits in relation to the normative and the expert maximum benchmarks amount to US\$20.6 and 32.9million, respectively, approximating to 3.75% and 5.96% average increases of the total health budget annually. Human resources alone account for 37% of the total additional budget, capital investment for 25%, and other recurrent resources which comprise EmONC equipment and laboratory needs account for 38%. Exceptionally, EmONC training involves expensive logistics. Historical expenditures revealed that training

one professional costs approximately US\$571 which is about 3months total salary of a Burundian medical doctor.

Assuming that all capital investments are made in year one (eg, in 2025) and that EmONC training sessions are conducted as per the Burundian strategy (eg, after recruitment and every 2 years), Burundi would commit 45% of the total additional budget to the first year and stretch the remaining balance over the next 4 years with higher expenditures occurring in the third and fifth years due to in-service EmONC training. In the second and fourth year, Burundi would invest between US\$1.5 and 3.5million corresponding to the minimum and the maximum benchmark scenarios. Annual budget estimates are provided in online supplemental material 6.

### DISCUSSION

The goal of this study was to evaluate the capacity challenges facing EmONC facilities and to develop EmONC investment proposals that promote resources



prioritisation and allocation. Strengthening the Burundian EmONC facilities is strategically sensible because these facilities manage about two-thirds of all obstetric complications among the 85% of deliveries currently taking place in health facilities.<sup>42 43</sup> Moreover, increasing EmONC facility capacity and performance could attract more maternal referrals and improve survival.

This study involved Burundian stakeholders who helped to develop three EmONC policy alternatives. However, all of the policy benchmarks examined arguably still set relatively low standards. Regarding human resources for instance, although we lack international standards for either numbers of delivery care professionals needed for maternity hubs,<sup>26 44</sup> the International Federation of Gynaecology and Obstetrics suggests that BEmONC facilities with 1000 deliveries per year should ideally have three delivery professionals per shift and there should be seven of these professionals per shift in CEmONC facilities that perform 3000 deliveries annually.<sup>26</sup> Examining prevailing workloads in Burundian EmONC facilities indicates that none of the staffing benchmarks examined meets these recommendations but the most demanding local benchmark, the expert maximum proposal, offers a progressive move for Burundi.

We found widespread and severe shortages of EmONC resources and highlighted disparities between facility types and provinces. The shocking levels of resource deficits and apparent imbalance with prevailing workloads raise questions about how or whether such facilities can sustain effective routine service delivery. For instance, five BEmONC and two CEmONC facilities are without a midwife or a maternity-specific nurse even though they are open 7 days and 24 hours. More generally, this study demonstrates that EmONC resources and measures of services provided are poorly aligned, with facilities facing severe understaffing often performing more deliveries and handling more complications. The findings of this study are important as they provide one assessment of the effectiveness of EmONC investments after 8 years of programmatic activity and suggest that Burundi continues to face structural challenges including resource prioritisation and allocation. In fact, despite policy efforts and strategic investments to address shortages and maldistribution of health resources,<sup>45</sup> many low/middle-income countries continue to face longstanding challenges to optimise resources allocation.<sup>45–47</sup>

Assuming that Burundi has a sufficient stock of unemployed health professionals and does not need to train additional cadres in the short run,<sup>48 49</sup> this country needs an estimated US\$32.9 million to address the higher (expert maximum) benchmark developed over the next 5 years. If capital investments are made in the first year (eg, in 2025) together with the first round of biennial EmONC training, the government is expected to spend 45% of the total budget in that year. Averaged across the 5 years, additional costs approximate to an annual 5.96% increase of the total health budget. Human resources account for 37%, capital investment for 25%, and other

recurrent resources comprising EmONC equipment and laboratory needs account for 38% of this additional budget. Our analyses show that EmONC training is very expensive, training one professional costs slightly higher than 3 months total salary of a full-time medical doctor. Alternative and potentially more efficient investments might be made to improve health worker skills and practice, for example, by investing in improving staff numbers and better supervision with on-site training by (visiting) senior professionals.

Burundi is likely to require financial support from current and potential EmONC partners such as UNFPA, WHO, UNICEF, The World Bank, JICA, The United States Agency for International Development and others. The results of this study could help to understand which and where EmONC resources are most needed. If the budget that can be mobilised proves insufficient to cover all the needs immediately, there may be options to target investments in human and capital resources to provinces and facilities with critical shortages and high demand for delivery care services highlighted in table 3. Such budgetary allocations should also consider the effects on equity and the consequences of any investments should be evaluated.

As described in online supplemental material 3, the government budget needed to strengthen EmONC facilities was estimated using tariffs obtained from a distorted market and the use of shadow pricing to adjust for market inefficiencies<sup>40 41</sup> may not have accurately addressed the problem particularly due to local currency fluctuations, unpredictable and unstable market tariffs, and monopolistic and oligopolistic powers. Also, the budget forecasting did not account for possible cost variability based on geographic location and urbanicity of EmONC facilities. Moreover, the study did not specifically address equity as we were limited in examining the supply of maternity and EmONC services and not potential demand and we have no information on wealth distribution across the populations accessing care.

## CONCLUSION

This study revealed that 8 years after initiating programmatic investments, Burundian EmONC facilities continue to face enormous capacity challenges likely to impair the system's performance. Even based on benchmarks that remain suboptimal, especially with regard to human resources, the country needs between US\$13.6 and 32.9 million to strengthen the capacity of these EmONC facilities for the next 5 years. Fortunately, the political determination and stakeholder commitment with many potential donors who support the country's efforts to advance the MNH agenda constitute an important asset. Studies should provide the basis for more detailed and continued work that can inform policy debates and progressively inform and evaluate efforts to improve and optimise EmONC resource allocation.

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## Supplemental materials

[Supplemental material 1 Table 1](#). List of study stakeholders

[Supplemental material 2 Table 1](#). List of important resources to support quality EmONC services

[Supplemental material 3](#). Market cost adjustment and shadow pricing

[Supplemental material 4 Table 1](#). Total budget forecast methods

[Supplemental material 5 Table 1](#). Correlations between health outcomes and EmONC resources

[Supplemental material 6 Table 1](#). Annual budget estimates by EmONC policy scenario



**Supplemental material 1 Table 1:** List of study stakeholders

Names	Position and institution
1. Dr Jean Baptiste Nzorironkankuze	Permanent Secretary, Ministry of Health (MoH)
2. Dr Oscar Ntihabose	Director General Health Services, MoH
3. Dr Ananie Ndacayisaba	Director of the RMNCAH Programme, MoH
4. Dr Zacharie Kubwimana	Director of Programme, MoH
5. Dr Theophile Bigayi	Deputy Director RMNCAH Programme, MoH
6. Prof Sylvestre Bazikamwe*	Professor of Gynecology and Obstetrics , University of Burundi
7. Dr Jeanine Ndayisenga**	Paediatrician Research Fellow, National Institute of Public Health
8. Dr Yolande Magonyagi	National Programme Officer SRH, United Nations Population Fund (UNFPA)
9. Dr Eugenie Siga Diane Niane	Programme Officer RMNCAH, World Health Organization (WHO)
10. Dr Brigitte Ndelema	National Programme Officer RMNCAH, WHO
11. Dr Aristide Bishinga	EmONC Specialist, Japan International Cooperation Agency (JICA)
12. Dr Dorothee Ntakirutimana	Health Specialist, United Nations Population Fund (UNICEF)
13. Dr Josiane Nijimbere	Scientist RMNCAH Programme, MoH
14. Dr Jean Claude Mugisha	Scientist RMNCAH Programme, MoH
15. Dr Innocent Nkurunziza	Secretary, MoH
16. Dr Anaclet Nahayo	Director of HIS, MoH
17. Olivier Gahungere, Mr	Statistician, RMNCAH Programme, MoH
18. Thierry Nzeyimana, Mr	Monitoring and Evaluation, RMNCAH Programme, MoH
19. Daniel Habonimana, Mr	Monitoring and Evaluation, RMNCAH Programme, MoH
20. Souverienne Bucumi, Mrs	Monitoring and Evaluation, RMNCAH Programme, MoH
21. Rose Simone Ndayiziga, Mrs	Scientist, National HIV/AIDS programme, MoH
22. Nadine Muhimbare, Ms.	Cabinet Secretary, MoH
23. Therence Nduwarugira, Mr	Scientist, UNFPA

\*He also represents the Burundian Association of Gynaecology-Obstetricians (AGOB)

\*\*She also represents the Burundian Association of Neonatology (ABUNE)

Supplemental material 2 Table 1. List of important resources to support quality EmONC services

Category	Maternal health care	Newborn health care
Physical space*	Adequate number of delivery rooms, maternity beds, and delivery tables. CEmONC facilities should also have an operating room and a functioning intense care unit (ICU).	Adequate number of newborn care beds and incubators. CEmONC facilities should also be able to offer neonatal ICU services.
Health services*	EmONC facilities should perform active management of the third stage of labour, breach deliveries, and provide VIH services.	EmONC facilities should provide newborn vaccination and Kangaroo Mother Care (KMC) services.
Equipment*	EmONC facilities should possess the delivery set, adult resuscitation kit, adult pulse oximeter, blood pressure machine, and forceps. CEmONC facilities should also have an ultrasound.	EmONC facilities should have a fetal monitoring machine, a neonatal or paediatric resuscitation kit and pulse oximeter, an infant weighing scale, and a phototherapy machine.
Drugs*	The following drugs should be available at all times: misoprostol, hydralazine, oxytocin, azithromycin, nifedipine, magnesium sulfate, ampicillin, gentamicin, metronidazole, and dexamethasone.	Sodium chloride and sodium gluconate eye drop should also be available at all times.
Cross-cutting resources		
Human resources*	Medical doctors, midwives, and nurses	
Supplies*	Oxygen, partograph, and clean and sterile gloves	
Communication	Computer, telephone, and access to internet	
Amenities	Toilets and water source in maternity common areas and electricity	
Guidelines	National protocol or guidelines for EmONC and essential neonatal care	
Referral system	Ambulance services	

Supplemental material 2 Table 1 summarises important resources tailored to Burundian context needed to support the provision of quality EmONC services. The availability of these resources depend on facility type and level. (\*) implies core resources directly linked to obstetric and newborn care.

### Supplemental material 3: Market costs adjustment and shadow pricing

The Burundian market is fundamentally distorted by monopolistic and oligopolistic powers, negative externalities, currency fluctuations, unpredictable and unstable market tariffs due to frequent and sudden tax increases, and imperfect market information.<sup>1-3</sup> The costs of all marketable resources used in this study were obtained from the Ministry of Health (MoH) and are therefore believed to be flawed by market imperfections and cannot serve as true economic estimates. Unlike marketable resources, salaries and overheads are fixed expenditures less likely affected by market imperfections. To adjust for market inaccuracies, we used shadow prices to estimate economic financial values of different resources.<sup>3,4</sup> Shadow prices are an alternative used to estimate the social economic values when market prices are impaired by market inefficiencies.<sup>3,4</sup> For instance, economic costs of marketable resources such as equipment were obtained by correcting their respective market tariffs using the prevailing black market for Burundian currency exchange rate: 1 US dollar officially exchanged at BIF 2,825 (2,810 – 2,840) against BIF 3,925 (3,850 – 4,000) black market value which corresponds to 38.94% (73.01% – 40 85%) cost increase.

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2. Rutten F, Bleichrodt H, Brouwer W, Koopmanschap M, Schut E. Handbook of health economics. Elsevier; 2001.
3. Drèze J, Stern N. Policy reform, shadow prices, and market prices. *Journal of public economics* 1990; **42**(1): 1-45.
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Supplemental material 4 Table 1. Total budget forecast methods

Resources	Costs adjustment and government budget calculation methods
Human resources	<p>The total government budget for delivery care professionals was calculated using monthly gross salaries, the annual salary growth rate, and the EmONC training cost. Firstly, we calculated the total annual government expenditure of each type of delivery care professional by summing their monthly gross salaries. Next, each annual gross expenditure was augmented by the annual salary growth rate (<math>\lambda</math>) to yield the gross expenditure for the subsequent year using <a href="#">Equation 1</a>.</p> $L_s = \sum_{i=1}^{n=3} \sum_{t=1}^{t=5} \lambda X_{(t-1)i} \tag{1}$ <p><math>L_s</math> is the government total salaries for delivery care professionals (labour) <math>X_i</math> corresponds to monthly gross salary of each type of delivery care professional <math>\sum_{i=1}^{n=1} X_{(t-1)1}</math> represents the annual gross salary of the preceding year for professional 1. For instance, the gross salary of a medical doctor in year 2 of employment is given by his gross salary in the first year of employment multiplied by <math>\lambda</math> <math>n = 3</math> implies three types of professionals: medical doctors, midwives, and nurses. <math>t = 5</math> means five years of investment which corresponds to the budget timeframe.</p> <p>Burundian EmONC guidelines prescribe that all delivery care professionals should receive an onset EmONC training and be recycled biannually until retirement. For instance, a medical doctor should be trained three times within the first 5 years of service and 16 times during 30 years of career. The final government expenditure on human resources was obtained by summing EmONC training costs <math>T_s</math> and salary costs <math>L_s</math>.</p>
Buildings and all marketable resources	<p>We corrected market tariffs using the black market currency exchange rate <math>\varphi</math> to yield shadow costs which are comparable to economic values and estimated the total budget of buildings and marketable resources using <a href="#">Equation 2</a>. Furthermore, we used the World Bank GDP inflation rate for Burundi to adjust the costs of recurrent marketable resources.</p> $C_T = \varphi \sum_{i=1}^n X_i \tag{2}$ <p><math>C_T</math> is the government total cost of acquisition of new buildings and of purchases <math>X_i</math> corresponds to individual market cost of item <math>i</math> <math>\varphi</math> corresponds to the black market correction factor 38.94% (37.01%–40 85%) <math>n</math> is the number of items (buildings and marketable resources).</p>
Non-marketable resources: overheads and maintenance costs	<p>Non-marketable resources are not affected by market imperfections. The total government endowment size for a 5-year investment was therefore obtained by summing respective costs until five years.</p>



Supplemental material 5 Table 1. Correlations between health outcomes and EmONC resources

	All EmONC facilities			BEmONC facilities			CEmONC facilities		
	Maternal deaths*	Maternal deaths due to complications*	Neonatal deaths due to complications*	Maternal deaths*	Maternal deaths due to complications*	Neonatal deaths due to complications*	Maternal deaths*	Maternal deaths due to complications*	Neonatal deaths due to complications*
Medical doctors							−0.02	−0.14	0.04
Midwives and nurses	−0.04	0.04	−0.08	−0.09	−0.07	−0.11	−0.06	+0.01	−0.12
Delivery rooms	−0.17	−0.13	−0.17	<b>−0.36*</b>	<b>−0.32*</b>	<b>−0.49*</b>	−0.15	−0.13	−0.14
Delivery tables	−0.16	−0.14	<b>−0.20*</b>	<b>−0.31*</b>	<b>−0.29*</b>	<b>−0.37*</b>	−0.16	−0.16	−0.21
Maternity beds	−0.13	−0.06		−0.25	<b>−0.27*</b>			−0.14	
Newborn care beds			−0.09			−0.07			−0.19
Incubators							−0.12	−0.14	−0.22
Functional ICU							−0.07	−0.16	−0.24

**Supplemental material 5 Table 1** summarises overall correlations between outcomes and selected EmONC resources and by facility type. Maternal deaths represent facility-based maternal mortality ratio obtained by dividing maternal deaths by the total number of deliveries multiplied by 100,000. Maternal deaths due to complications are ratios of maternal deaths due complications divided by the total number of maternal complications. Neonatal deaths due to complications were calculated similarly using neonatal complications. Significant correlations are in bold and highlighted with a star. Coefficients ( $r$ ) < |0.3| denote weak correlation, those between |0.3| and |0.5| translate moderate relationships, while  $r$  > |0.5| correspond to strong relationships.

Supplemental material 6 Table 1. Annual budget estimates by EmONC policy scenario

	Year 1 budget	Year 2 budget	Year 3 budget	Year 4 budget	Year 5 budget	Total Budget
Human resources						
Expert minimum	3,348,480,000.00	1,601,114,400.00	3,443,147,832.00	1,698,622,266.96	3,543,580,934.97	13,634,945,433.93
Burundian norms	6,605,280,000.00	3,132,518,400.00	6,790,493,952.00	3,323,288,770.56	6,986,987,433.68	26,838,568,556.24
Expert maximum	13,233,600,000.00	6,418,548,000.00	13,613,104,440.00	6,809,437,573.20	14,015,720,700.40	54,090,410,713.60
Capital resources						
Expert minimum	9,262,666,548.67	-	-	-	-	9,262,666,548.67
Burundian norms	15,072,566,867.26	-	-	-	-	15,072,566,867.26
Expert maximum	21,112,620,849.56	-	-	-	-	21,112,620,849.56
Other needs						
Equipment	1,404,314,982.29					1,404,314,982.29
Laboratory exam	2,491,948,460.18	2,491,948,460.18	2,491,948,460.18	2,491,948,460.18	2,491,948,460.18	12,459,742,300.89
Total budget BIF						
Expert minimum	16,507,409,991.14	4,093,062,860.18	5,935,096,292.18	4,190,570,727.14	6,035,529,395.15	36,761,669,265.78
Burundian norms	25,574,110,309.72	5,624,466,860.18	9,282,442,412.18	5,815,237,230.74	9,478,935,893.85	55,775,192,706.67
Expert maximum	38,242,484,292.03	8,910,496,460.18	16,105,052,900.18	9,301,386,033.38	16,507,669,160.57	89,067,088,846.33
Total budget US\$						
Expert minimum	6,087,138.82	1,509,324.71	2,188,578.04	1,545,280.92	2,225,612.94	13,555,935.44
Burundian norms	9,430,501.80	2,074,032.85	3,422,918.29	2,144,379.79	3,495,375.63	20,567,208.36
Expert maximum	14,101,988.80	3,285,762.51	5,938,768.88	3,429,903.79	6,087,234.39	32,843,658.37

Supplemental material 6 Table 1. summarises annual budget needs by policy scenario. (\*) Supplies, amenities, vehicles, maintenance, and overheads costs are routine expenditures and are explicitly excluded from the total additional EmONC investment budget needs. However, these costs are important as the government needs to bear in mind that EmONC facilities will continue to require regular investments for supplies, maintenance, and overheads commensurate with inflation and growth in facility-level deliveries and needs. Supplies include essential drugs, oxygen, partographs, clean and sterile gloves, and blood for transfusion. Amenities comprise water and toilet sources in maternity wards and electricity. Vehicles are medicalised ambulances.