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COUNTRY CASE STUDY

Bangladesh

A success story of integrating pulse oximetry into IMCI

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Case study focus

This case study focuses on the incorporation and expansion of pulse oximetry within the Integrated Management of Childhood Illnesses (IMCI) programme in Bangladesh. The effectiveness of IMCI heavily depends upon the diagnostic proficiency of healthcare providers, to mitigate missed and misdiagnoses and the administration of inappropriate treatments.(1) It is noteworthy that hypoxaemia is prevalent in over 30% of children diagnosed with pneumonia – a key focus condition of IMCI.(2,3) And pulse oximetry, a non-invasive method for estimating and monitoring peripheral oxygen saturation (SpO2) at the point of care, is the simplest way to measure hypoxaemia.(4,5)

Key messages

- *It is more likely for the policy makers to be convinced on taking any decision if the underlying problem, possible solution along with the experience of that solution in other relevant contexts is presented before them.*
- *The overall process of integrating pulse oximetry in IMCI settings was led by NNHP & IMCI programme with catalytic support from icddr,b and other development partners. The country ownership and government leadership facilitated the process of introduction and scale up of pulse oximetry in Bangladesh.*
- *The extensive stakeholder mapping exercise was crucial to identify the key stakeholders regarding child health services in Bangladesh. To successfully introduce pulse oximetry in Bangladesh, it was important to involve and engage key stakeholders at every stage of the process. This ensured that all relevant parties were informed and invested in the initiative, which in turn increased the likelihood of success.*
- *The overall update to the national IMCI guideline based on the existing evidence and not only focusing on inclusion of pulse oximetry, created the momentum for successful integration of pulse oximetry in IMCI settings.*
- *Setting a benchmark prior to conducting the implementation research created a sense of accountability among the service providers.*

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The integration of pulse oximetry in IMCI settings can therefore significantly improve the classification accuracy of pneumonia.(5) In recognition of the importance of pulse oximetry, the World Health Organisation (WHO) revised the IMCI guidelines in 2014 to incorporate pulse oximetry in the assessment of pneumonia symptoms in children aged 2-59 months, supplementing clinical assessment.(6,7) The impact of this integration is substantiated by a study conducted in Malawi, which reported that 69% of hypoxaemic children at health centres would have been deemed ineligible for referral if assessed solely based on clinical assessments without pulse oximetry.(8)

Presently, however the WHO's 2014 IMCI guidelines include pulse oximetry only as a footnote, suggesting that if an oximeter is available, it should be used as part of the clinical pneumonia assessment. The 2024 recommendations have not changed this. The large-scale adoption and implementation of pulse oximetry within IMCI has so far been limited due to various concerns and barriers. This case study, therefore, focuses on the successful example of Bangladesh, where IMCI is the primary healthcare strategy for children presenting with pneumonia.

The Bangladeshi government has made joint efforts to expand the scope of IMCI healthcare units by including pulse oximetry. This initiative holds significant relevance for Bangladesh, and other low to middle-income countries (LMICs) can glean valuable insights from it. The case study underscores the potential of pulse oximetry as a critical tool in improving the diagnosis and treatment of pneumonia within the IMCI framework.

Country Context

Demography, economy, and epidemiology

Indicator	Recent value	Data source
Total population	165 million	Population and Housing Census 2022 [13]
Total under-five population	15,590,973	Population and Housing Census 2022 [13]
Under-five mortality	31 deaths per 1,000 live births	BDHS 2022 [14]
Life expectancy (m:f)	Overall: 72.4 years Male:70.8 years Female: 74.2 years	SVRS 2022 [15]
GDP per capita	2,688 US$	The World Bank [16]
Healthcare expenditure per capita	54 US$	BNHA 1997-2020 [17]
Income status	Lower-middle-income Country	The World Bank [18]

Table 1: Overview of Bangladesh's demography and economy

The national source of causes of deaths for all ages in Bangladesh is the Sample Vital Registration System (SVRS). However, SVRS does not follow the World Health Organization (WHO) standard tool for verbal autopsy to report causes of death distribution,(9) and it does not follow the International Classification of Diseases (ICD-10) codes for assigning causes – somewhat limiting comparisons to other settings.(10)

According to the most recent all-age causes of death data from SVRS 2021,(11) five causes contributed to around half of all deaths in Bangladesh: heart attack (23%); cause-specific mortality rate (CSMR) 103 per 100,000 population); respiratory disease (12%; CSMR 52 per 100,000 population), brain stroke (10%; CSMR 45 per 100,000 population), asthma (6%; CSMR 29 per 100,000 population) and pneumonia (5%; CSMR 24 per 100,000 population) - Figure 1.

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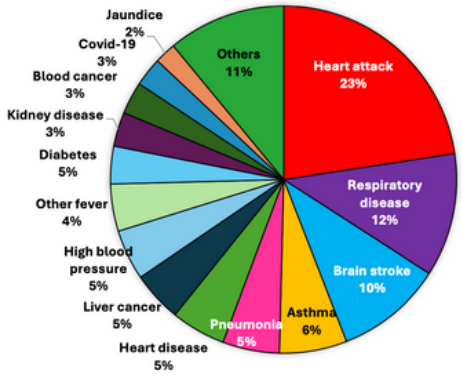

Figure 1: Causes of deaths in Bangladesh, presented in percentages from the 2021 SVRS

Data from other large population surveys and Health and Demographic Surveillance Sites (HDSS) in Matlab, Chakariya, Baliakandi, Sitankundu and Dhaka have reported similar top causes of death, with strokes, heart disease and respiratory diseases consistently in the top five. Of particular note for this case study, key causes of death linked to oxygen needs such as respiratory disease, asthma and pneumonia consistently account for over 1 in 5 deaths.(11,12)

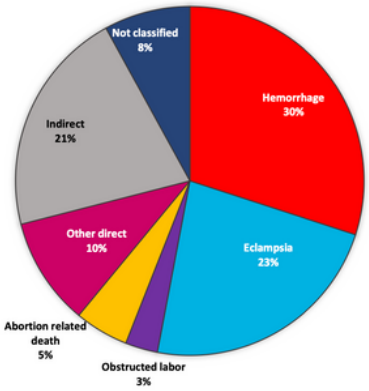

Figure 2: Causes of maternal deaths, presented in percentage from BMMS 2016 (n=175)

The Bangladesh Maternal Mortality and Health Care Survey (BMMS) 2016 revealed that around 6,577 women die annually in Bangladesh due to maternal causes – Figure 2. Two top causes haemorrhage (31%) and eclampsia (23%) accounted for half of the maternal deaths.(19) Indirect causes, including stroke, cancer, heart disease, and asthma, contributed to 21% of the maternal deaths.(20)

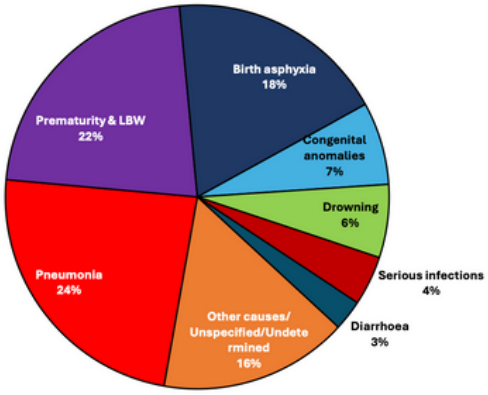

Figure 3: Causes of under-five deaths, presented in percentage from BDHS 2022 (n=502)

The Bangladesh Demographic and Health Survey (BDHS) 2022 is a nationally representative survey which provide causes of under-five deaths.(14) This survey uses the WHO's 2016 verbal autopsy questionnaire, and trained physicians assigned the causes of 502 under-five deaths using ICD-10 codes.(10) According to the BDHS 2022, two-thirds of under-five deaths are caused by pneumonia, prematurity and low-birth-weight (LBW) and birth asphyxia,(14) with pneumonia contributing 24% of under-five deaths (approximately 26,000 deaths). Prematurity and LBW (22%) accounted for 25,000 deaths and birth asphyxia (18%) accounted for 21,000 under-five deaths (Figure 3).

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Hypoxaemia burden

Hypoxaemia, based on the WHO definition of SpO2<90%, is a common complication of pneumonia and other acute lower respiratory infections (ALRIs). The most recent global estimate of the prevalence of hypoxaemia for LMICs was 31% among all children with WHO-classified pneumonia.(3) The pooled estimate from the five papers from Bangladesh in this systematic review estimated 52% of children with WHO-classified pneumonia were hypoxaemic (Figure 4), considerably higher than the global estimate. However, 3 of the 5 studies were based on hospitalised patients, and one study included both hospitalised and non-hospitalised patients, therefore representing a severely sick population.

A study conducted in outpatient clinics of Bangladesh reported 3% of children aged 3–11 months with suspected pneumonia had hypoxaemia based on the WHO-recommended cut-off of SpO2<90%. Another 8% of the children had an SpO2 of 90-93%.(21) Another secondary analysis of data from 2,646 patients admitted to icddr,b-Dhaka Hospital, a secondary level referral hospital located in Dhaka, conducted in 2021, reported a high hypoxaemia prevalence of 40% among children hospitalised with severe pneumonia on admission.(22)

The seasonal variation in hypoxaemia prevalence between 2014 and 2017 observed in the icddr,b-Dhaka Hospital found no notable seasonal pattern, although the average annual prevalence increased from 32% in 2014 to 51% in 2017 (Figure 5). There could be several factors contributing to this. The introduction of

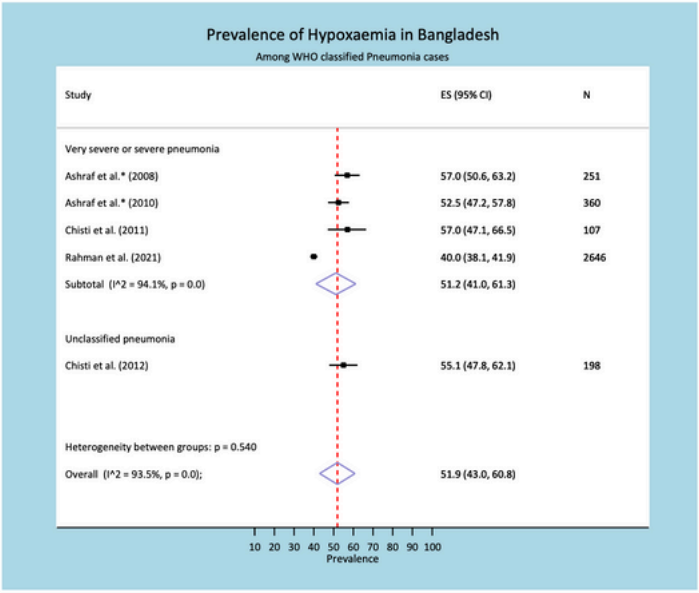

Figure 4: Hypoxaemia prevalence among children with WHO-classified pneumonia in Bangladesh by clinical severity. *Studies where SpO_2 cut-off is greater than 90%.

pneumococcal conjugate vaccines (PCVs) and Haemophilus influenzae type b (Hib) vaccines in national immunization programs across several countries, including Bangladesh, has significantly reduced the incidence of serious bacterial pneumonias. Consequently, respiratory syncytial virus (RSV) and other viruses have become more dominant pathogens causing severe pneumonia in children. This shift in pneumonia aetiology may impact clinical features, including hypoxemia. Approximately 20% of hospitalized children with RSV-associated acute LRIs exhibit hypoxemia. (23)

The changes in hypoxemia prevalence could also be attributed to improved pneumonia care-seeking practices in Bangladesh. Parents are now more aware of pneumonia-related symptoms and complications, leading to better identification of complicated cases through hospital-based assessments.(24)

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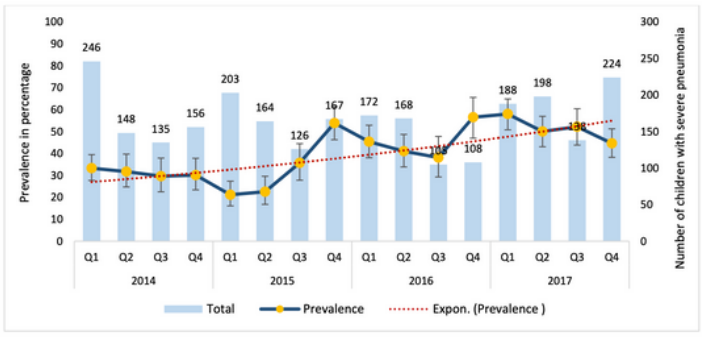

Figure 5: Hypoxaemia prevalence among children aged 2-59 months admitted to icddr,b Dhaka Hospital with WHO-defined severe pneumonia between 2014 and 2017

Among these children, 6% died during the hospital stay, and 9% were referred to higher-level facilities due to clinical deterioration. Hypoxaemia was found to be the strongest predictor of mortality with 11 times higher odds of death in these children.(22)

An observational study was also conducted at a secondary level referral district hospital in Kushtia of Bangladesh on children aged 0-59 months who were admitted to the paediatric inpatient unit or who visited the emergency department (unpublished data). Among the 2,025 admitted patients, the prevalence of hypoxaemia was 42% among children aged 2 to 59 months with critical illness or clinical severe infection, and 40% among fast breathing pneumonia patients of 0 to 59 days, compared to 18% among children of the same age without any signs of pneumonia. For children aged 2 to 59 months, 11% of admitted children with severe or non-severe pneumonia had hypoxaemia, compared to 4% among admitted children without pneumonia (Figure 6). This analysis again found hypoxaemia to be the strongest predictor of mortality with three times higher odds of death.

Health system

The administrative structure of Bangladesh is hierarchical, cascading from divisions to villages. Each division is subdivided into districts, then upazilas (sub-districts), and down to unions and villages. There are a total of seven divisions, 64 districts, 495 upazilas, and approximately 4,671 unions and 87,320 villages in Bangladesh. The healthcare system in Bangladesh adopts a pluralistic approach, involving a diverse range of stakeholders. These include the government, profit-driven private sector entities, non-profit organizations, and international development agencies.(25)

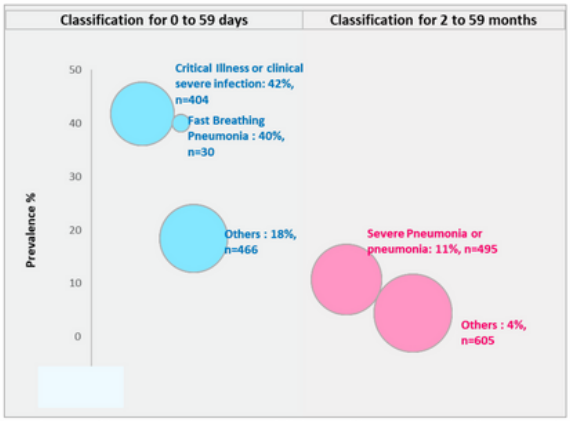

Figure 6: Prevalence of hypoxaemia among children with pneumonia disaggregated by age and clinical severity at Kushtia District Hospital in Bangladesh

The Ministry of Health and Family Welfare (MOH&FW) oversees the health system. It has two major wings: The Health Services Division, which manages clinical and public health services, and the Medical Education and Family Welfare Division, which focuses on family planning work, training and capacity development, and enhancing research programmes.(25) Under the MOH&FW, there are five regulatory bodies and nine implementing

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agencies. The two major implementing agencies are the Director General of Health Services (DGHS) and the Directorate General of Family Planning (DGFP).(25) All six levels of the Bangladeshi government—national, divisional, district, sub-district, union, and village—are under the supervision of the Directorate General of Health Services and the Directorate General of Family Planning.

The capacity of secondary-level district hospitals ranges from approximately 100 to 250 beds. Beneath this, facilities known as Upazila health Complexes have 30-50 beds,(25) and at the union level, Union Health and Family Welfare Centres (UH&FWCs) facilities are responsible for providing fundamental preventative and curative treatment, and are maintained by Sub-Assistant Community Medical Officers (SACMO). Family Welfare Visitors (FWV) are those who are primarily concerned with the reproductive and maternal health of the communities they visit. Community Health Care Providers (CHCP) are responsible for the operation of Community Clinics (CCs) and provide basic healthcare, as well as health education and family planning services.

Position	Number
Total DGHS Staff	78,227
Sanctioned Posts	115,272
Doctors	26,791
Community Healthcare Providers (CHCPs)	13,948
Sub-assistant Community Medical Officers (SACMOs)	3,616
Health Inspectors (HIs)	893
Assistant Health Inspectors (AHIs)	3,433

Table 2: Workforce available in healthcare [25]

Population per registered physician	1,410
Health Workforce	Per 10,000 population
Registered Physician	7.10
Doctors working under DGHS	1.59
Medical technologist	0.34
Community and domiciliary health workers under DGHS	2.17

Table 3: Overview of Bangladesh Population-Health Workforce ratio DHGS 2020 [25]

The Government of Bangladesh provides financial support to the public healthcare system, and subsidises care. Patients are also obliged to pay out-of-pocket payments, particularly for outpatient services. Bangladesh is struggling with one of the largest burdens of out-of-pocket expenses globally, with more than 63% of overall health costs incurred by households, resulting in financial fragility.

Access to health services has been found to be unequal across geographic location, income level, gender, and there is a clear gap between urban and rural areas.(25) In June 2023, the Bangladesh National Parliament approved the budget for FY2023-24, with an increased allocation for the health sector. The health sector received 5% of the full budget, representing a 27.9% increase from the previous year.(26) Additionally, the Government initiated free healthcare services to those living below the poverty line to protect them from the financial hardship of illness. This policy is reflective of the Government of Bangladesh's ambition of universal health coverage for all by 2032.(27)

Private healthcare in Bangladesh spans profit-oriented enterprises, non-profit organizations (NGOs), and informal practitioners, such as village doctors and various unqualified providers. The private sector offers a diverse range of health facilities, from individual practitioners' offices to high-end tertiary-level hospitals adhering to international standards. (25) Bangladesh's private health business has expanded rapidly in recent years, improving public health. As of June 2020, Bangladesh had 5,577 registered private hospitals and clinics, and 10,727 private diagnostic centres. There are a total of 91,537 beds in registered private hospitals and clinics.(25)

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The majority of targeted commodities are manufactured and marketed by local pharmaceutical companies, and the majority of Bangladeshis obtain their prescriptions privately. Privately purchased drugs are the most common source of narcotics for disadvantaged people in rural and urban areas.

The Bangladesh National Newborn Health Programme and Integrated Management of Childhood Illness Programme (NNHP & IMCI) launched a significant initiative between 2020 and 2021 to improve access to medical oxygen.(28) This was aimed at enhancing care for newborns and children, led by the government, with support from UNICEF. As part of this initiative, the General Hospital in Tangail and the Medical College in Chattogram were upgraded, including the establishment of a liquid oxygen (LOX) facility and infrastructural improvements, and training were provided to doctors and nurses to effectively manage hypoxemia in children. Additionally, new oxygen indicators were added to the District Health Information System (DHIS2) for structured reporting.

The initiative expanded to cover a total of 13 of 64 districts. Its success led the Government to acknowledge the need for national guidelines and training modules, and as a result, oxygen therapy has been included in the operational plan for the next sector programme, aiming to enhance the overall quality of paediatric care standards.

COVID-19

On March 08, 2020, the Institute of Epidemiology, Disease Control and Research (IEDCR) declared the first confirmed case of COVID-19 in Bangladesh.(29-31) By January 2024, there were 2,047,051 cases (Figure 7) and 29,481 deaths (Figure 8) officially reported in Bangladesh.(32) A nationwide lockdown was imposed on March 26, 2020 which extended until August 31, 2020.(33,34) Concurrently, the government introduced a TK.1.04 trillion (approximately US$9.4 billion) package to mitigate COVID-19's financial impact, encompassing cash, food, subsidized food, tax relief, and policy support for firms of all sizes. Awareness-raising measures were implemented, and various mobile applications were launched during the lockdown.(35)

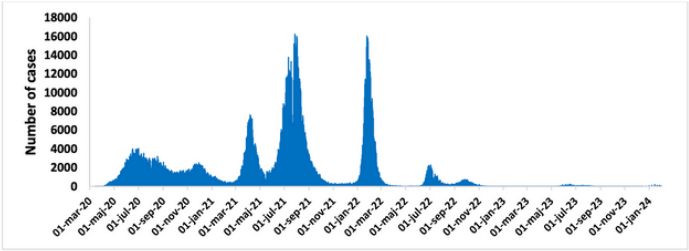

Figure 7: Trend in COVID-19 cases in Bangladesh (# of cases)

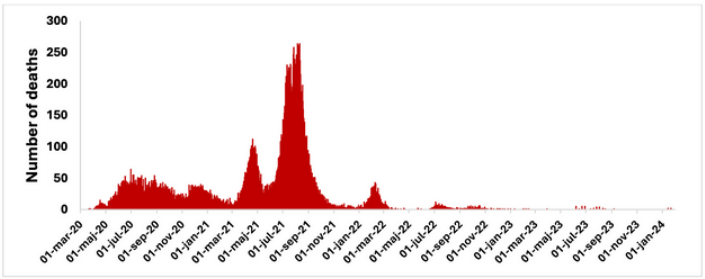

Figure 8: Trend in COVID-19 deaths in Bangladesh (# of deaths)

The Government of Bangladesh also developed a National Preparedness and Response Plan for COVID-19.(36) According to this plan, triage and screening facilities were made available for respiratory diseases in all hospitals, with special areas designated for identifying suspected cases. These centres then referred to the hospitals designated for managing COVID-19

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patients, and suspected cases with comorbid conditions and critical cases were referred to specialised hospitals designated for advanced management of COVID-19 patients. In addition, all government hospitals had isolation units to quarantine patients, and special isolation wards for this purpose.

With the support of global partners such as the WHO, Serum Institute of India, and countries including Japan and Bulgaria, Bangladesh administered 160 million COVID-19 vaccine doses by January 2022 and fully immunized more than 70% of its population.(37) This was achieved through various channels, including purchases, donations, and the COVAX programme.(38,39) In February 2022, a large-scale vaccination initiative, supported by WHO and UNICEF, vaccinated 17 million people, significantly increasing the country's overall immunization rate. Dhaka, the capital, received the highest number of COVAX vaccine doses.(40) More than 90% of Bangladesh's population had received at least one COVID-19 vaccine dose (150,049,129 people) by 2024, with 131,182,263 having a second, 65,6732,743 a third, and 569,825 a fourth dose.(37,41)

Oxygen supply and clinical use landscape in Bangladesh

In Bangladesh, the regulation of oxygen is a collaborative effort involving various national and international entities. The Directorate General of Health Services (DGHS) under the Ministry of Health and Family Welfare (MOH&FW) leads this initiative, with significant contributions from the National Electro-Medical Equipment Maintenance Workshop and Training Centre (NEMEMW&TC) and the Central Medical Store Depot (CMSD). Other government bodies, such as the Public Works Department (PWD), City Corporations, and municipalities, also play crucial roles in maintaining the oxygen system. Development partners, such as UNICEF, WHO, USAID, The World Bank, Asian Development Bank, the UK Foreign, Commonwealth & Development Office, and the Government of Canada have made significant contributions to this cause.

The availability and distribution of medical-grade oxygen is reliant on the nation's domestic production capabilities, which are based on the generation of liquid oxygen (LOX). This LOX is transported from manufacturing locations using tankers and is subsequently stored in Vacuum Insulated Evaporator (VIE) tanks at healthcare facilities. These VIE tanks enable a centralized supply of oxygen within hospitals and clinics. The country is equipped with 76 VIE tanks, dispersed across a range of healthcare institutions, from specialized and tertiary hospitals to district-level health centres.

Additionally, numerous health facilities are equipped with onsite oxygen generating plants, with both Pressure Swing Adsorption (PSA) and Vacuum Swing Adsorption (VSA) technologies. Notably, the surge of the COVID-19 pandemic catalysed the establishment of over 100 oxygen generating plants, considerably enhancing capacity.

The regulatory framework governing the establishment and operation of medical oxygen plants mandates securing a license from the Director General of Drug Administration (DG-DA). A critical precondition for this licensing process is obtaining a gas purity certification from the Chemical Engineering Department of the Bangladesh University of Engineering and Technology (BUET). As of now, four LOX

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production and supply entities have acquired the necessary licensing, including Linde Bangladesh Ltd, which operates two facilities, Spectra Oxygen Ltd, Bangladesh Industrial Gas Limited, and Islam Oxygen Limited.

Furthermore, the importation and use of oxygen concentrators, cylinders, and manifold oxygen cylinder systems, while not directly licensed by the DG-DA, are subject to safety regulations requiring a fire safety certificate from the Department of Explosives within the Ministry of Energy and Mineral Resources. Prior to initiating the operational licensing application with the DG-DA, potential medical oxygen producers must first secure a gas purity certification from BUET's Chemical Engineering Department. The establishment and maintenance of Medical Gas and Vacuum Pipeline Systems in healthcare facilities are guided by the "PWD Standard Operating Procedure 2018 For Electro-Medical Works," as outlined by the Public Works Department. This procedural manual serves as a cornerstone for ensuring the safe and effective installation of medical gas systems.

In response to the increased demand during the COVID-19 pandemic, an additional 14 local industrial LOX manufacturers were granted No Objection Certificates (NOCs) by local authorities, after obtaining the purity certificate from local authorities to supply oxygen to various facilities (Table 4).

During the COVID-19 pandemic, several companies also increased their LOX production capacity. For example, GPH Ispat's Green factory in Chattogram, the largest oxygen plant in Bangladesh, produces 300 metric tons of medical oxygen daily - 10% in liquid form for medical use.

Abul Khair Group's Ispat unit in Chattogram produces 260 metric tons of oxygen daily, dedicating 30-40 tons for medical-grade oxygen. SPECTRA Oxygen Limited, which has been operational since 1999, supplies both liquid and gaseous medical gases. Linde Bangladesh, with two plants in Chittagong and Narayangonj, produces 90 metric tons of liquid oxygen daily. Meghna Group recently obtained a license and started producing 40 metric tons of liquid oxygen. KSRM produces 24,000 cubic meters of oxygen daily for cylinder use.

Sl.No.	Name and Address of the Manufacturers	NOC Issue date	Status Capacity
1	M / S Abul Khair Steel Melting Ltd. Sitalpur, Sitakunda, Chottogram	29-7-2020	Functional 260 Ton / Day
2	M / S D R Industries Ltd. 175, Muradpur, Modanpur, Bandar, Narayanganj	09-08-2020	Functional 19 Ton / Day
3	Union Oxygen Limited Lakhon Khola, Bander, Narayanganj	04-05-2021	Functional 9.26 Ton / Day
4	AK Oxygen Ltd. Barpa, Rupganj, Narayanganj	10-12-2020	Functional 1200m³ / Hour
5	Padma Oxygen Ltd, Thangrband, Modhyapara, Kaliakaoir, Gazipur	17-01-2021	Functional 8 Ton / Day
6	Sonargoan Steel Fabricate Ltd., Meghna Industrial Economic Zone, Tipordi, Sonargoan, Narayanganj	06-04-2021	Functional 56.8 Ton / Day
7	Arcade SS Oxygen Ltd., Ashulia, Savar, Dhaka	21-04-2021	Functional
8	Refat Oxygen Company (Pvt) Ltd., Kunda South, Keraniganj, Dhaka	27-04-2021	Functional 150m³ / Hour
9	Linde Bangladesh Ltd., Shipyard, Khulna	28-04-2021	Functional 1960m³ / Hour
10	Kabir Oxygen Limited, Johanabad, Bhatiary, Sitakunda, Chottogram	28-04-2021	Functional 1.6 MTon / Day
11	Spectra Oxygen Ltd., 64 Isali, Udhuli , Shebaloy , Manikganj, (Additionally during Covid crisis on rental, Basis at Shalauddin Oxygen Ltd , Kanchpur ,Narayanganj)	28-04-2021	Functional 400m³ / Hour
12	Diamond Steel Product Co. (Pvt) Ltd., Kanchpur, Sonargoan, Narayanganj	12-05-2021	Functional 1400m³ / Day
13	North Bengal Oxygen Plant, Majira Bypass, Dompukur, Shajahanpur, Bogura	03-08-2021	Functional 130m³ / Year
14	Associated Oxygen Limited, Khadampara, Madambibir Hat, Bhatiary, Sitakunda, Chottogram	03-08-2021	Functional 9800m³ / Day

Table 4: List of medical oxygen manufacturers received DGDA's NOC (as of January 2024)[42]

Until November 2021, the Central Medical Store Depot (CMSD) had procured or was in the process of procuring 50 VSA oxygen plants, and 52 PSA plants. The CMSD is responsible for supplying oxygen cylinders, currently covering 353 upazila-level hospitals, while the Ministry of Health and Family Welfare procured 3,136 oxygen concentrators and installed 76 liquid medical oxygen VIE tanks at different health facilities. Currently, 172 facilities have a central oxygen supply system, either by a manifold system, VIE tank, or oxygen plant.(42)

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The National Electro-Medical Equipment Maintenance Workshop and Training Centre (NEMEW&TC), operating under the MOH&FW, oversees the maintenance of medical equipment, including oxygen systems in public health facilities. This responsibility extends to 596 facilities of varying tiers, from district hospitals and medical college hospitals to specialized and upazila health complexes, managed by a team of 62 staff members, including 14 biomedical experts. To ensure oxygen safety, the MOH&FW is considering the introduction of an accreditation system for hospital standards, which would encompass oxygen standards and safety measures. Given the limited resources in public facilities, it is crucial to improve the quality of care by effectively managing hypoxaemia in neonates, children, and adults.

To address this issue, the Directorate General of Health Services (DGHS) introduced the "National Guidelines on Use of Oxygen Therapy for Management of Newborns and Paediatric Hypoxaemia" in 2020. This comprehensive guideline, developed by the National Neonatal Health Programme (NNHP) and Integrated Management of Childhood Illness (IMCI) programme under the DGHS, provides a framework for managing newborn and paediatric hypoxaemia.(43) However, there were no specific guidelines developed for adult patients, apart from the guidelines on oxygen therapy for COVID-19.

Sl . No.	Funding Support	Number of plants	Type
1	Government	3	PSA 500 litre / min
2	Government	40	20 VSA and 20 PSA
3	Global Fund	29	PSA
4	ADB	30	VSA
Total		102	

Table 5: Oxygen Generating Plants Procured by MOHFW (till November 2021) [42]

Introduction of pulse oximetry into IMCI settings

Introduction of IMCI in Bangladesh - a history of early adoption

The Government of Bangladesh has prioritized the reduction of respiratory infections, diarrhoea, and malnutrition among children under five years of age. This decision was influenced by the positive results from a multi-country evaluation of the IMCI guidelines recommended by the WHO in 1997.(44)

In response to these findings, the Government established a national steering committee under the Deputy Programme Manager of the Control of Diarrhoeal Disease Programme.(45) The committee's mandate was to introduce IMCI services in Bangladesh. This led to the implementation of the Facility-Based Integrated Management of Childhood Illness (FB-IMCI) programme in 2001, marking a significant milestone in the country's healthcare journey.(44,46) The success of the FB-IMCI programme led to its expansion in 2004, resulting in substantial improvements in healthcare quality and utilization rates.

By the end of 2014, the Government in partnership with various development partners, had expanded IMCI services to all 64 districts and over 420 upazila health complexes (Figure 9).(47,48) Recognizing the unique needs of its rural population, the Government introduced a Community-Based IMCI (CB-IMCI) strategy in 2003.(49) The NNHP & IMCI programme of DGHS, responsible for implementing IMCI services across the country, played a crucial role in this process.

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In 2018, icddr,b, with technical assistance from the University of Edinburgh, initiated a research project to introduce pulse oximetry in routine IMCI settings. As part of this project, icddr,b organized a series of workshops with the NNHP & IMCI programme to sensitize them regarding the role of pulse oximetry in managing childhood illnesses. Consequently, the NNHP & IMCI programme agreed to lead the process of integrating pulse oximetry in IMCI settings of Bangladesh.(49) In the sensitization workshops, icddr,b presented the underlying problem related to pneumonia management in Bangladesh, pulse oximetry as a possible solution along with the experience of implementing pulse oximetry in other relevant contexts. This comprehensive approach convinced the NNHP & IMCI programme to take the leadership role in integrating pulse oximetry in IMCI settings of Bangladesh.

The central role of Government and research collaborations

icddr,b conducted a comprehensive desk review of IMCI-related documents and organized interviews with key informants to identify 15 stakeholder organizations at the national level and 16 at the district level. These stakeholders encompass government health programs, professional societies, UN agencies, and a range of non-government organizations (NGOs) both locally and internationally, as well as health service providers. Following this, icddr,b collaborated with the NNHP & IMCI team to organize a workshop aimed at mapping stakeholders based on a Power-Interest matrix. This exercise led to the identification of organizations with high power and high interest at both national and district levels, which were deemed crucial for the process of integrating pulse oximetry in IMCI settings.

At the national level, high power and high interest were held by DGHS, WHO, Save The Children, UNICEF, and icddr,b. At the district level, the high power-high interest group comprised of the Civil Surgeon (district level health manager), Upazila Health and Family Planning Officer (sub-district level health manager), doctors, nurses, Sab assistant community medical officers (Paramedics), and the Resident Medical Officer (RMO) – Figure 10.

It is notable that in sub-districts, where responsibility for enacting on policies takes place, the power firmly lies with Government structures and the presence of international and national NGOs are virtually non-existent. While at the National level, the prominent role of icddr,b signifies the importance with which research and evidence-informed decision making has held to date in IMCI programming.

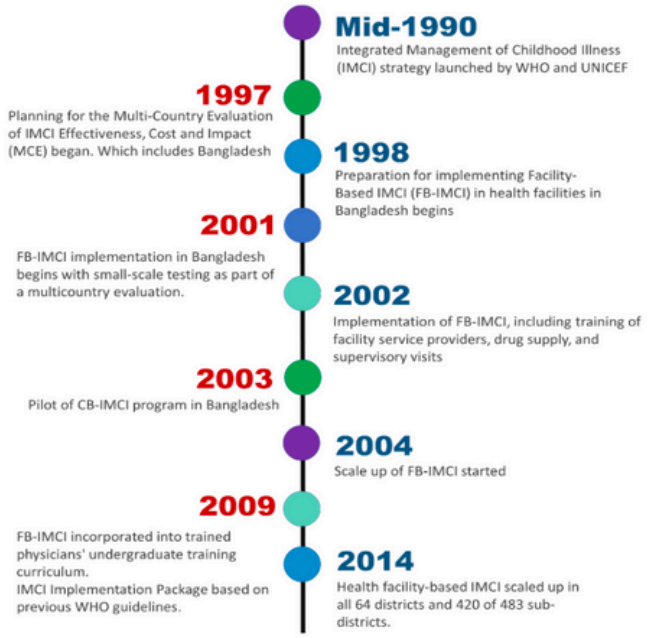

Figure 9: Journey of IMCI in Bangladesh

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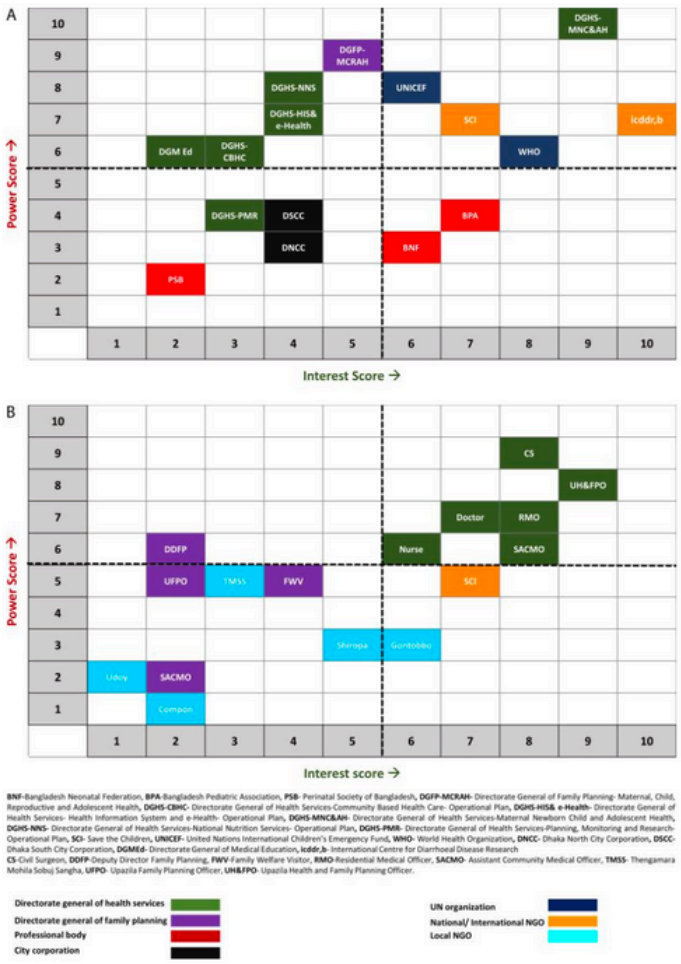

BNF-Bangladesh Neonatal Federation, **BPA**-Bangladesh Pediatric Association, **PSB**- Perinatal Society of Bangladesh, **DGFP-MCRAH**- Directorate General of Family Planning- Maternal, Child, Reproductive and Adolescent Health, **DGHS-CBHC**- Directorate General of Health Services-Community Based Health Care- Operational Plan, **DGHS-HIS& e-Health**- Directorate General of Health Services- Health Information System and e-Health- Operational Plan, **DGHS-MNC&AH**- Directorate General of Health Services-Maternal Newborn Child and Adolescent Health, **DGHS-NNS**- Directorate General of Health Services-National Nutrition Services- Operational Plan, **DGHS-PMR**- Directorate General of Health Services-Planning, Monitoring and Research-Operational Plan, **SCI**- Save the Children, **UNICEF**- United Nations International Children's Emergency Fund, **WHO**- World Health Organization, **DNCC**- Dhaka North City Corporation, **DSCC**-Dhaka South City Corporation, **DGMEd**- Directorate General of Medical Education, **Icddr,b**- International Centre for Diarrhoeal Disease Research **CS**-Civil Surgeon, **DDFP**-Deputy Director Family Planning, **FWV**-Family Welfare Visitor, **RMO**-Residential Medical Officer, **SACMO**- Assistant Community Medical Officer, **TMSS**- Thengamara Mohila Sobuj Sangha, **UFPO**- Upazila Family Planning Officer, **UH&FPO**- Upazila Health and Family Planning Officer.

Figure 10: Power-Interest mapping of national (A) and district level (B) stakeholders[50]

In addition to the mapping, a thirteen-member working group was established, chaired by the Programme Manager of the NNHP & IMCI programme. This group comprised members from DGHS, UN organizations, and development partners. The working group decided to update the overall national IMCI guideline and IMCI implementation package based on the existing global guidelines, rather than solely focusing on the introduction of pulse oximeters. They also recommended conducting implementation research to test the feasibility of introducing pulse oximetry in routine IMCI settings. This decision emphasizes the continued value placed on evidence and evidence-generation and reflects long-standing collaborations.

Upon reviewing the WHO guidelines from 2009 and 2014, the group decided to adopt and update the criteria classification of pneumonia in children. After careful consideration of the contextual relevance, rationale, and operational feasibility, the group incorporated these changes into the national IMCI guidelines. This led to an extensive update of the National IMCI Implementation Package, which includes the IMCI chart booklet, IMCI service registers, referral forms, training manuals, reporting forms, monitoring checklist, drug list, job aids, equipment, logistic and medicine list, trainer's guide, student handbook, and manager toolkit. A total of 24 documents were updated, with pulse oximetry included in the updated IMCI implementation package.

The NNHP & IMCI programme also organised orientation sessions with IMCI master trainers on the updated IMCI chart booklet and training manuals. The master trainers carefully reviewed the IMCI chart booklet and training manuals and provided feedback. Subsequently, feedback was received and incorporated from the members of National Newborn Technical Working Committee for Newborn Health and the National IMCI Technical Working Committee, the highest-level technical committees regarding newborn and child health in Bangladesh (Figure 11).

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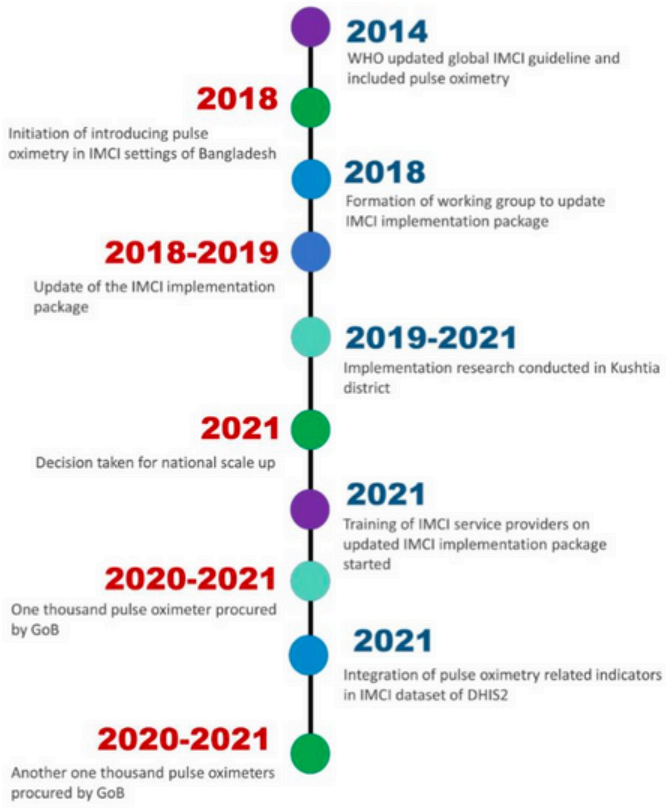

Figure 11: Journey of introducing pulse oximetry in IMCI services of Bangladesh

Centring evidence in policy decision-making

In order to determine whether it would be possible to incorporate pulse oximetry into IMCI, the NNHP & IMCI programme, in collaboration with icddr,b, conducted implementation research.(50) Kushtia district was selected for the "District Implementation Model" initiative to introduce pulse oximetry in routine IMCI settings because of its significant patient turnover and long-standing IMCI services. Eleven health facilities including district hospital, upazila health complexes and union level health facilities were chosen as the study sites. The IMCI service providers in these health facilities received training on the updated IMCI Implementation Package prior to the start of the implementation evaluation. Pulse oximeters were also introduced in the IMCI corners of these selected health facilities. This study assessed WHO implementation outcome variables such as adoption, feasibility, fidelity, appropriateness, acceptability and sustainability based on a pre-set benchmark for each indicator.

The study revealed that the IMCI service providers almost universally used the pulse oximeter on all eligible children. The IMCI service providers were successful in conducting pulse oximetry within a short period of implementation, with good accuracy and minimum challenges. Pulse oximetry was also well accepted by the caregivers.

The success was largely attributed to the early and strategic involvement of stakeholders, including IMCI service providers. They were sensitized and actively participated in all stages, from the design and development to the implementation of pulse oximetry in routine IMCI. Continuous engagement via training, support supervision, and performance appraisal workshops resulted in a sense of ownership and acquisition of necessary technical skills among the IMCI service providers, which have likely contributed to the positive findings.

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These positive findings in turn convinced the policy makers of Bangladesh to scale-up pulse oximetry to the whole country, using lessons learnt. The process of scale up included training of the IMCI service providers on updated IMCI implementation package, procurement of pulse oximeters using government funding and integration of pulse oximetry related indicators in the routine DHIS2. One of the key informants stated:

"The pulse oximeter's integration has been successful, enabling accurate detection of severe pneumonia in babies with low oxygen levels. Despite the challenges faced by our staff, this tool has improved our diagnostic capabilities and patient care. While data accuracy is not yet perfect, we anticipate gradual improvements."

The importance of a comprehensive training strategy

Since December 2019, the NNHP & IMCI programme in Bangladesh has been working on a comprehensive training initiative. This initiative has successfully trained 4,872 service providers, including doctors, nurses, and paramedics, on the updated IMCI Implementation Package, with a particular emphasis on the use of pulse oximetry. The program operates across various training venues, including Dhaka and several medical colleges outside the capital. Each venue hosts a pool of 5-6 experienced individuals who further train healthcare providers at designated facilities. The training duration has been optimized over time, with doctors now receiving five days of training, nurses, SACMOs, and paramedics six days, and basic health workers two days. One of the key informants mentioned that:

"This isn't a one-time event, but a continuous cycle of initial training, refresher courses, and mentoring. As knowledge can fade, regular refreshers are necessary. This ongoing learning not only maintains up-to-date information but also motivates our service providers, addressing a key deficiency."

The programme ensures continuity of learning through annual training and refresher courses, catering to both new recruits and existing staff. Funding for these training programs is sourced from development partners and the government budget, with government-funded sessions typically held from February to June. International organizations such as UNICEF and WHO support the IMCI training programs. Annual performance appraisal meetings engage data-involved personnel, including doctors, nurses, SACMOs, basic health workers, and statisticians from Upazila Health Complexes. These individuals receive training on IMCI datasets and updates from the Management Information System.

Procurement of pulse oximeters with government funding

The NNHP & IMCI programme decided to do a phase-wise scale up of pulse oximeters, where in the first phase, pulse oximeters will be procured for district hospitals and upazila health complexes. In the second phase pulse oximeters will be procured for union level health facilities. As part of the decision for national

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scale-up, pulse oximeters are procured through the Central Medical Store Depot (CMSD) using government funds from the programme budget, with no specific model prioritized. Instead, purchases are made based on specifications that fit within the budget. One of the respondents mentioned that:

"Our purchases are made according to the Public Procurement Act, with CMSD as our procurement agency. We are required to buy items from suppliers who fit within our allocated budget. We didn't prefer a specific pulse oximeter model, but we procured it based on the implementation research conducted in Kushtia. However, due to budget constraints, we procured the minimum which our government could afford."

Over the course of two fiscal years, 2020-21 and 2021-22, the programme procured 2,000 handheld pulse oximeters with child probes (model: Yongkang YK-820A). Despite challenges such as the lack of a fixed budget and the need to ensure the procurement of high-quality pulse oximeters with child probes, the NNHP & IMCI programme has successfully distributed these pulse oximeters to health facilities at both district hospitals and upazila health complexes. The NNHP & IMCI programme also retained provision of procurement of pulse oximeters in the next health sector programme (2024-2029) with plans to introduce pulse oximetry in the union level health facilities in the second phase.

Integration of indicators in DHIS2

The NNHP & IMCI programme organised meetings with the Management Information System (MIS) of DGHS to update the DHIS2 IMCI dataset. This led to an agreement between NNHP & IMCI programme and MIS to introduce a new IMCI dataset in DHIS2 including indicators for hypoxaemia detection. Currently, the NNHP & IMCI programme is arranging regular trainings and workshops to improve the quality of the new IMCI dataset. One deputy programme manager of the NNHP & IMCI programme is assigned to ensure the quality of new IMCI dataset. One of the key informants mentioned that:

"In January 2021, the IMCI dataset was introduced in DHIS2 throughout Bangladesh. Initially, there were some mistakes with data being uploaded to the old dataset. However, series of orientation arranged on the new system for health managers and statisticians of the health facilities responsible for data entry, the transition has been successful. Now, all data, including pulse oximeter-related information, is being received via the new IMCI dataset in DHIS2."

The impact of COVID-19

The COVID-19 pandemic resulted in cessation of the implementation activities due to a government-imposed lockdown in March 2020. Following a five-month intermission, the NNHP & IMCI programme demonstrated initiative by resuming activities and ensuring the timely completion of the implementation. Health managers were directed to reactivate all events, adhering to a revised plan that incorporated necessary precautions to mitigate the spread of the virus. However, the COVID-19 pandemic resulted in increased awareness regarding the impact of low oxygen saturation in blood and usefulness of pulse oximetry among the service providers and caregivers.

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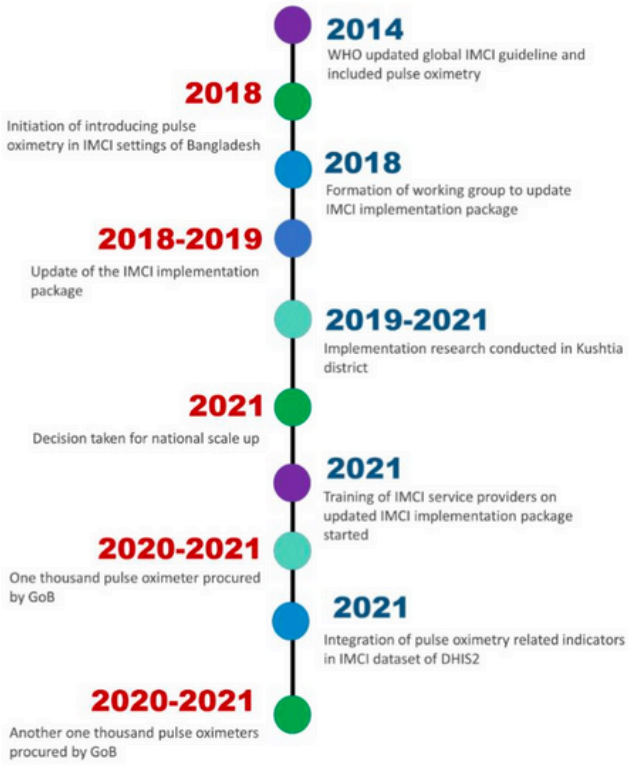

Figure 11: Journey of introducing pulse oximetry in IMCI services of Bangladesh

Additional methods informations

This case study was conducted based on the information received from key informants' interviews and the information collected from the documents mentioned by the key informants (Table 6). We first purposively approached the Hospital Services Management programme, who are responsible for ensuring oxygen security in the hospitals of Bangladesh, and the NNHP & IMCI programme of DGHS, who are responsible for implementing IMCI services across the country. We collected information of the personnels who were involved in the process of pulse oximetry integration in IMCI settings of Bangladesh from the NNHP & IMCI programme. A total of 14 participants were identified and all of them were interviewed.

Programme Manager of Hospital Service Management (HSM)
Ex-Programme Manager of NNHP & IMCI
Programme Manager of NNHP & IMCI
Deputy Programme Manager, Monitoring and Data Quality, NNHP & IMCI
Deputy Programme Manager, Training and Child Injury, NNHP & IMCI
Deputy Programme Manager, Newborn Health, NNHP & IMCI
Deputy Programme Manager, Monitoring & Data Quality
Deputy Programme Manager, Coordination & Logistics
Deputy Programme Manager, Admin & Finance
Deputy Programme Manager, Newborn Health
Former Advisor, Pneumonia Centinel Commitment (PCC) Project, Save the Children
Advisor, Save the Children
Health Specialist, World Health Organization
NPO, MNCAH, WHO Bangladesh

Table 6: Key informant interview participants

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ABOUT THE COMMISSION

Announced in September 2022, *The Lancet Global Health* Commission on Medical Oxygen Security provides a thorough exploration of medical oxygen coverage gaps, with recommendations to ensure that no patient dies for lack of access to this essential medicine, including during public health emergencies like COVID-19.

The Commission was led by 18 Commissioners - multi-disciplinary academics with clinical, economic, engineering, epidemiological, and public policy expertise - representing all regions of the world. Forty Advisors representing United Nations and global health agencies, donors, academic institutions, and non-governmental organizations provided guidance. A large global network of Oxygen Access Collaborators provided constant input to the Commission and included representatives from industry and Ministries of Health. Special consultations were conducted with patients, caregivers, and clinicians to ensure that their voices and experiences shaped the Commission's recommendations.

An Executive Committee coordinated the work of the Commission and included representatives from **Makerere University**, Uganda; **International Centre for Diarrheal Disease Research** (icddr,b), Bangladesh; **Murdoch Children's Research Institute** (MCRI), Australia; **Karolinska Institutet**, Sweden; and **Every Breath Counts Coalition**, USA.

You can find the Commission report here and the advocacy package here, including:

- ***Report with Comments***
- ***Policy Brief (English, French, Spanish, Arabic, Chinese, and Russian)***
- ***Spotlight Brief: Access to Medical Oxygen Scorecard ($ATMO_2S$)***
- ***Spotlight Brief: Patient and Caregiver Testimonials***
- ***Spotlight Brief: 10 Oxygen Coverage Indicators***
- ***Spotlight Brief: 20 Priority Areas for Oxygen Innovation***
- ***Country Case Studies***

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