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ANALYSIS OF PAEDIATRIC SURGICAL NEEDS IN LOW AND MIDDLE INCOME COUNTRIES: PROPOSALS BASED ON MULTICENTRIC EXPERIENCES ON THE GROUND

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SUMMARY

ABSTRACT

Si definiscono gli LMICs nazioni che possiedono un GNI minore di $1,026 e come tali sono caratterizzate da livelli di Sanità elementari ed inferiori agli stati HICs.

A conoscenza del fatto che la letteratura circa le necessità della chirurgia in LMICs è scarsa e consapevoli che l'impatto sulla Salute Globale della stessa è notevole, la tesi si prefigge come obiettivo lo studio dei bisogni della Chirurgia Pediatrica in LMICs basandosi su esperienze multicentriche sul campo, confrontando e comprendendo le attività delle ONG in ambito della Cooperazione allo Sviluppo, e in particolare della Cooperazione Sanitaria Internazionale, rispetto a ciò che è già stato analizzato nella scarsa letteratura presente.

Dopo la descrizione dettagliata delle missioni chirurgiche da noi analizzate e prese in considerazione, nello studio è presente una descrizione il più dettagliata possibile delle principali patologie di pertinenza chirurgica che si riscontrano nelle missioni chirurgiche, soffermandosi sugli interventi che si possono realizzare.

L'obiettivo dello studio è quello di comprendere se le attività e le missioni sono adeguate per l'inserimento delle stesse nel sistema sanitario locale allo scopo di potenziarne l'autonomia, la rete, la conoscenza e la preparazione dei professionisti.

Conoscendo il DALYs (Disability-adjusted life years) come indice principale per la valutazione dell'impatto umano, finanziario ed economico delle patologie di pertinenza chirurgica e delle cure chirurgiche, e sapendo che attualmente è la misura standard per la valutazione the Global Burden of Disease, lo studio parte dalla necessità, che si sta rivelando fondamentale nell'ultimo ventennio, di inserire la Chirurgia Pediatrica nel contesto della Salute Globale come intervento di notevole e basilare importanza per dare modo alle popolazioni svantaggiate di poter avere un accesso completo alla Salute, "lavorando oggi su un problema che si rileverà domani". Spesso ci si scontra con quelle che sono delle idee sbagliate a proposito della Pratica Chirurgica applicata alla cooperazione. Prima tra tutte il pregiudizio che la chirurgia sia indirizzata ad una piccola parte del Global Burden of Disease, che abbia costi elevati da un punto di vista economico, ed infine che possa essere attuata solo per portare una forma di sollievo a breve termine.

In verità, l'obiettivo è quello di portare un piccolo contributo alla conoscenza di tali aspetti, sostenendo e proponendo, come alcuni Autori e programmi WHO, che la chirurgia, e in

particolare la chirurgia pediatrica dovrebbe essere riconosciuta come un importante intervento della Salute Globale.

I metodi utilizzati prevedono un'analisi statistica dettagliata di quelli che sono i casi operati per anno (dal 2004 al 2019 in diversi LMICs diversificati per le organizzazioni prese come riferimento o con cui l'Unità Operativa (U.O.) di Chirurgia Pediatrica dell'Azienda Ospedaliero Universitaria di Ferrara ha collaborato (*Smile Train Italia, Operation Smile Italia, Chirurgo e Bambino Onlus, Fes Fundaciò,* U.O. Chirurgia Pediatrica di Ferrara).

Si è quindi analizzata la distribuzione percentuale dei casi operati per anno secondo le voci: Congenital Conditions (Condizioni congenite), Malignancies (Neoplasie), Injuries (Traumi) e Other (Altro: come Infezioni chirurgiche ed altre patologie) come indicato in letteratura.

Pur limitandosi ad un'analisi qualitativa dei risultati poiché i dati a disposizione prevedono alcune lacune dovute ai metodi differenti di raccolta e registrazione degli stessi da parte delle diverse ONG, si è proceduto a calcolare la deviazione standard pesata delle varie classi di intervento. Si è poi passati alla valutazione della varianza nell'andamento per anno soffermandosi su un'analisi temporale delle percentuali di intervento delle varie missioni a breve temine di tutte le associazioni, ed infine più specificatamente delle missioni chirurgiche a breve termine di Chirurgo e Bambino Onlus, della quale siamo in possesso del numero di dati maggiore. Ciò poi è avvenuto singolarmente per la missione a lungo termine svolta nel 2004 in Kenya dall' U.O. di Chirurgia Pediatrica di Ferrara.

Le percentuali di casi rispecchiano il trend globale tipico delle patologie nei LMICs. Seppur il numero di casi possa essere sottoposto ad un errore dovuto alla "iper-specificità" delle missioni chirurghe dipendente dagli obiettivi delle singole ONG, i nostri dati sono distribuiti in modo analogo alla letteratura, e vedendo che il nostro campione è comunque vicino al trend della letteratura, possiamo considerarlo significativo.

Possiamo affermare chiaramente e senza dubbio che l'attività chirurgica pediatrica, per andare incontro a bisogni di salute di tipo globale, deve essere inserita come parte integrante delle cure dei LMICs.

Ci si è soffermati sulle differenze pratico-organizzative delle missioni a lungo e breve termine, pur valorizzando la necessità che esse vengano organizzate per evitare che gli obiettivi (seppur diversificati) non vengano perseguiti e raggiunti in assenza di esse. Dobbiamo tuttavia ricordarci che non basta sperare che la promozione della salute nei

LMICs possa essere relegata alle attività di cooperazione che già sono ben conosciute come funzionali allo stato della salute del cittadino e della comunità locale.

Il peso non indifferente di una patologia pediatrica chirurgica non trattata, che si trasmette sull'intera vita dell'individuo in termini di qualità della vita, avrà un risvolto in termini economici e sociali al pari di quelle patologie tropicali ormai sdoganate nell'immaginario collettivo del paese povero e delle quali la risoluzione è stata inserita già da lungo tempo negli obiettivi mondiali della Salute Globale da parte del WHO.

Uno sforzo concreto deve essere applicato a più livelli, consci che solo un bambino felice e in salute, potrà diventare un adulto in grado di provvedere alla comunità in tutti i suoi aspetti. Le patologie del bambino trattabili chirurgicamente, soprattutto congenite (ma anche sequele di traumi o precedenti interventi chirurgici), vanno inesorabilmente a precludere uno sviluppo fisiologico dell'individuo. Non ci si ferma solamente allo stato di salute come assenza di malattia, ma dobbiamo sforzarci di osservare l'individuo come parte integrante di un microcosmo che è la sua esistenza, e un macrocosmo che è la comunità di appartenenza, spesso fragili entrambi dovuti ad un contesto socio-sanitario-culturale-economico precario, debole o inefficiente. Una patologia non affrontata ora, si ripercuoterà sul domani. Si ripercuoterà infatti con una compromissione dell'accrescimento sia biologico che culturale. Il bambino non curato avrà più difficoltà all'accesso alla scolarizzazione, al mondo del lavoro e spesso all'accettazione stessa della comunità di appartenenza. La nostra proposta è quindi quella di inserire la Chirurgia Pediatrica, in modo attivo e sempre più completo, in quella che è la valutazione del Burden of Disease, andando a scardinare i preconcetti di cui la Chirurgia, e più specificamente la Chirurgia Pediatrica, è oggetto.

Ciò in cui ci si deve impegnare con uno studio attivo e sistematico è lo sviluppo e l'integrazione delle pratiche chirurgiche pediatriche, al di là dei preconcetti e pregiudizi in tutti quei sistemi sanitari carenti, apportando alti standard di cura ovunque. Nell'imminente futuro non basteranno le missioni chirurgiche, se non affiancate da specifici percorsi di teaching e di training costante del personale locale, i quali devono ricoprire notevole importanza nell'organizzazione delle missioni stesse tanto quanto lo studio delle necessità del territorio in cui si opera.

Con tutti i limiti specifici, le missioni a breve e a lungo termine non devono essere abbandonate, perché sono, ad ora, l'unica via per un approccio che vedrà il suo sviluppo nella diffusione della chirurgia, e in particolare della chirurgia pediatrica, in quei paesi dove il contesto socio-economico è più deficitario.

PREAMBLE

WHO Member States are grouped into 6 WHO regions: African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, and Western Pacific Region.

For analytical purposes, the World Economic Situation and Prospects (*WESP*) classifies all countries of the World into one of three broad categories: developed economies, economies in transition and developing economies. The composition of these groupings, is intended to reflect basic economic country conditions.[1]

Geographical regions for developing economies are as follows: Africa, East Asia, South Asia, Western Asia, and Latin America and the Caribbean.

Nevertheless, WHO Member States have been classified by their level of development into 4 income groups (accordingly they have been grouped in low, lower-middle, upper-middle, and high; as in *Table 1*) based on the World Bank list of analytical income classification of economies for the fiscal year, which is based on the Atlas Gross National Income (GNI) per capita estimates (up-dated annually on July) which measures income generated by the country's citizens, and it is the total domestic and foreign output claimed by residents of a country.

We will prefer to use these last definitions during all description (speaking about Low and Middle Income Countries as LMICs).

According to the World Bank, low-income countries are nations that have a per capita gross national income (GNI) of less than $1,026.

In contrast, the high-income group has the highest income in the world with a GNI per capita of at least $12,476. The upper-middle-income group has per capita incomes between $4,038 and $12,475. The lower-middle-income nations have GNI per capita of $1,026 to $4,035.[2]

Low and Middle Income Countries (LMICs) are often synonymous with underdeveloped countries, also known as developing countries, emerging markets, or newly industrialized countries. These countries receive development aid, which is financial aid given by governments or agencies to boost and support the economic, political, social, and environmental development in other countries. Bilateral aid is given directly from the donor country to the recipient country, and multilateral aid is given to an international organization which then distributes the aid to developing countries.

LMICs face struggles relating to a poor economy.

Issues related to poor economic situation include below average life expectancy, high infant mortality rates, insufficient vaccination campaigns, poor educational outcomes, degrading

High-income		Upper middle income		Lower middle income	Low-income
Australia	Lithuania[b]	Albania[b]	Jordan	Armenia	Bangladesh
Austria	Luxembourg	Algeria	Kazakhstan	Bolivia	Benin
Bahrain	Malta	Angola	Lebanon	Cameroon	Burkina Faso
Barbados	Netherlands	Argentina	Libya	Cape Verde	Burundi
Belgium	New Zealand	Azerbaijan	Malaysia	Congo	Central African Republic
Brunei Darussalam	Norway	Belarus	Mauritius	Côte d'Ivoire	Chad
Canada	Oman	Bosnia and Herzegovina	Mexico	Djibouti	Comoros
Chile[b]	Poland	Botswana	Montenegro	Egypt	Democratic Republic of the Congo
Croatia	Portugal	Brazil	Namibia	El Salvador	Eritrea
Cyprus	Qatar	Bulgaria	Panama	Georgia	Ethiopia
Czech Republic	Republic of Korea	China	Peru	Ghana	Gambia, The
Denmark	Russian Federation[b]	Colombia	Romania	Guatemala	Guinea
Equatorial Guinea	Saudi Arabia	Costa Rica	Serbia	Guyana	Guinea-Bissau
Estonia	Singapore	Cuba	South Africa	Honduras	Haiti
Finland	Slovak Republic	Dominican Republic	Thailand	India	Kenya
France	Slovenia	Ecuador	The former Yugoslav Republic of Macedonia	Indonesia	Kyrgyz Republic
Germany	Spain	Gabon	Tunisia	Lesotho	Liberia
Greece	Sweden	Hungary[c]	Turkey	Mauritania[b]	Madagascar
Hong Kong SAR[d]	Switzerland	Iran, Islamic Republic	Turkmenistan	Moldova	Malawi
Iceland	Taiwan Province of China	Iraq[b]	Venezuela, RB	Morocco	Mali
Ireland	Trinidad and Tobago	Jamaica		Nicaragua	Mozambique
Israel	United Arab Emirates			Nigeria	Myanmar
Italy	United Kingdom			Pakistan	Nepal
Japan	United States			Papua New Guinea	Niger
Kuwait	Uruguay[b]			Paraguay	Rwanda
Latvia[b]				Philippines	Sierra Leone
				São Tomé and Principe	Somalia
				Senegal	Tajikistan
				Sri Lanka	Tanzania
				Sudan	Togo
				Syrian Arab Republic	Uganda
				Ukraine	Zimbabwe
				Uzbekistan	
				Vietnam	
				Yemen, Rep.	
				Zambia	

Table 1. Economies by per capita in GNI, World Economic Situation and Prospects 2014

infrastructure, environmental and climate conditions, and poor health outcomes with a very limited access to public health system.

These low-income countries suffer high rates of illnesses and infections due to lack of clean water, low levels of sanitation, malnutrition, and lack of access to quality medical care.

There are currently 32 countries in the low-income country category. For example, Somalia is at the bottom of the low-income country list, with a GNI per capita of $130.[2]

In the largest part of LMICs there are armed conflicts defined as a contested incompatibility that concerns government and/or territory using armed force between two parties, results in at least 25 battle-related deaths in one calendar year, by International Humanitarian Law that distinguishes two types of armed conflicts in international armed conflicts (opposing two or more States) and *non-international armed conflicts* (between governmental forces and nongovernmental armed groups, or between such groups only).[3]

At this point, we have to remember that victims of contemporary conflicts are civilians in 93% of cases and children in 43% of cases.[4]

International Development Cooperation

Here, in fact, are inserted the multiples activities and actions of the International Cooperation, defined as collaborative relationship between institutions to work toward shared objectives through a mutually agreed division of labour. At the country level, this means engaging under government leadership with national stakeholders and external partners (including international development agencies) in developing, implementing, and monitoring a country's own development strategy.[5]

The development cooperation policy is the set of policies implemented by a government that aim to create the necessary conditions for lasting and sustainable economic and social development in another country.[6]

The development cooperation policy stems from the need to guarantee respect for human dignity and to ensure the economic growth for all peoples: in this perspective, development cooperation policy is implemented by governments with the aim of obtaining the favorable and necessary conditions for the lasting development of another country.

For this reason, we can say that the International Cooperation and Development is an integral part of a country's foreign policy, as evidenced by the fact that it often belongs to the Ministry of Foreign Affairs (M.A.E. in Italy).[6]

According to the idea formulated by the Nobel Prize Amartya Sen, poverty is conceived as "various forms of deprivation"; the development strategy must therefore guarantee a "pro-poor" policy, giving to poor people opportunities to have easy access to basic services, land and infrastructure through the equitable distribution of resources.

The "Millennium Declaration" of U.N., signed in year 2000, sets the eradication of poverty as an objective of Development Cooperation Policy, which is therefore understood as a condition in which the state of deprivation is predominant, with reference to the following aspects:

- Income;
- Nutrition;
- Health;
- Education;
- Participation in social life.[7]

The Italian Government focuses on international cooperation and social and health care to build peace, promising a stable and lasting commitment in promoting local health systems in accordance with international objectives (Millennium Development Goals) regarding the following points:

- two thirds reduction in infant mortality;
- improvement of maternal health with a reduction of three quarters of maternal mortality;
- fight against HIV / AIDS, malaria and other epidemic diseases;
- availability of drinking water and environmental hygiene.

From a health perspective, services must be strengthened by using existing bilateral and multilateral channels, together with global health initiatives; vaccines must spread; the crisis of human resources in the health sector must be addressed; ensure fair access to basic health services; fight female discrimination; provide research funding in developing countries.

Italy has adopted a new law for cooperation to development (Law 125/2014) which recognizes the role that cooperation has taken on in recent decades as a qualifying foreign policy tool for promoting peace and human rights, sustainable development and partnership between Countries.

By tradition, healthcare is one of the main areas of intervention of Italian Cooperation because it intersects decisive factors for the development of society, from education to socio-economic determinants.

As it is enshrined in the web-site of M.A.E.:

> *Development cooperation, as an integral part of our country's foreign policy, is founded on two priority bases. The first one is the solidarity need to guarantee the protection of life and human dignity to all inhabitants of the planet. The second one sees cooperation as the method of establishing, improving and consolidating relations between different Countries and different Communities. This exchange between peers, in addition to increasing the mutual knowledge necessary to understand the real needs of the local communities receiving the interventions, promotes relationships aimed at economic, but also social and human growth, respectful of the environment and of the different cultures and which knows protect common resources such as water, food and energy, so as to ensure the growth of the well-being of populations and pursue peace between peoples.*
>
> *The Italian development cooperation policy also aims to pursue these objectives together with economic, cultural and security diplomacy, consolidating the role and image of our country in the world.*

The Principles of Italian cooperation are also a guide for civil society organizations and for all of those institutions that participate in development partnerships in Italy in the healthcare field, offering itself as a tool for operator training faced with complex global health challenges:

1) *The Italian Cooperation promotes socio-economic development based on the approach of human rights, giving priority to Low and Middle Income countries and to disadvantaged population groups. (Social protection and contrast to social-economic and gender inequalities)*
2) *The Italian Cooperation recognizes health as a fundamental and human right and it promotes universal access to quality health services to meet needs of health without incurring financial difficulties related to their payment. (Universal health coverage: fair access and financial protection)*

3) *The Italian Cooperation pursues the strengthening of health systems in a universalistic perspective with reforms oriented towards equity, solidarity and social inclusion. (National health systems)*
4) *The Italian Cooperation considers the self-determination of the communities, indispensable for health promotion, disease prevention and programming, use and quality verification of health services. (Participation of the communities)*
5) *The Italian Cooperation promotes the international partnership in scientific research and in training between institutions and homologous actors or bearers of different knowledge. (Training, research, knowledge networks and cultural promotion)*
6) *International humanitarian and human rights legislation according to the principles of impartiality, neutrality and humanity, guides the interventions of the Italian Cooperation for assistance in emergency situations. (Natural disasters)*
7) *The Italian Cooperation promotes ownership of development policies from partner countries, the alignment of donors to policies and health national plans and harmonization of donor actions to increase their effectiveness and reduce fragmentation and dependence on countries' external aid partner. (The effectiveness of International Cooperation for Global Health).*[8]

In order for these interventions to translate into effective long-term measures, it is essential that developing countries implement a coherent policy and therefore corrupt or weak governments are excluded because they are unable to prevent conflicts; not forgetting a particular attention for what concerns the environmental degradation, because the world population is growing and the environment suffers the consequences linked to the mass displacements from rural regions towards urban areas with consequent pressure on food and water resources, thus feeding new conflicts.

Indeed, aid effectiveness depends not only on economic policies, but also on factors such as vulnerability to conflict or natural disaster.[6]

The implementation of the Development Cooperation Policies can be carried out by governmental, national or international organizations, and by non-governmental organizations (NGOs). In the several players of the International Health Cooperation, as far as Italy is concerned, there are also other kind of actors such as ONLUS (non-profit organization of social utility) and private institutions.

History of NGOs

A Non-government organization (NGO) is any organization or group (local, national or international) of citizens that does not belong to government structures and is engaged in the social sector and development cooperation not for profit.

Italian legislation (d.lgs 460/1997) qualifies NGOs and non-profit organizations as organizations that operate on the base of the principles of solidarity between peoples, for the promotion and respect of the fundamental rights of humanity.

The universe of NGOs and non-profit organizations is heterogeneous and complex. Simplifying, we can distinguish two types of organizations:

- those of opinion (*advocacy*), which promote a certain cause or movement of opinion at various levels,
- *operational organizations*, whose primary purpose is the design and execution of cooperation projects.

With regard to the latter, Italian Legislation (law 49/1987) provides that they can receive public funding only after obtaining formal recognition by the M.A.E., after a selective investigation aimed at assessing their reliability.[6]

NGOs of International Cooperation have had an intense development since the Second World War with a peak in the early 60s, born as a spontaneous associative movements in response to the growing interest in the problems of LMICs and with the aim of providing a common political vision to these issues.

However, it is mainly from the 1980s that NGOs have established themselves and they have extended their scope. Due to the state immobility, caused by the Cold War, NGOs have affirmed the so-called "*droit d'ingerence*" (right of interference) by intervening in situations of humanitarian crisis.

The right of interference is justified by the universal declaration of human rights, according to which all human people are entitled to receive humanitarian assistance.

Thanks to their independence, direct knowledge of the territory and ability to go where traditional donors are unable to arrive, NGOs have been recognized by governments and public opinion as an important tool for implementing humanitarian and cooperation interventions.[6]

In fact, they are among the main actors of International Cooperation for the possibility of being inserted and impacting concretely in the political and social processes of the

communities in which they operate, critically and independently from governments and international organizations.

A very important concept to underline is that today, the movement of NGOs is a very different reality from the concept of volunteering commonly understood as they have acquired a highly professional structure aimed at carrying out cooperation activities and formed by professionally cooperating figures.

Furthermore, as their importance increased and the areas of intervention expanded, they had the need to manage considerable resources and manage them effectively and transparently.[6]

The purpose of these organizations is to support public health in the developing country in which they operate, and in this sense the objectives will be manifold and with difficulties and implementation characteristics that are well diversified and distinct.

1. INTRODUCTION

One of the most important methods for assessing the human, financial and economic impact of surgical conditions and surgical care is the Disability-adjusted life years (DALYs) which is currently the standard measure for assessing the global burden of disease. DALYs include both mortality and morbidity components by combining years of life lost (YLL) due to premature mortality with years lost due to disability for individuals living with a disease (YLD).[9]

However, we have to remember that DALYs little fail to capture other critical areas of disease impact including[10] the physical, psychological and financial impact on families caring for a sick child; the financial impact on households or individuals seeking surgical care, which recent estimates have found to be immense.[11]

$$DALY = YLL + YLD$$

(YLL=Years of Life Lost; YLD=Years of Life with Disability)

The DALY is not the only existing metric of disease burden, but it remains the choice of policymakers and development specialists in resource allocation for global health.[12]

The Global Burden of Disease Study (GBD) is the most comprehensive worldwide observational epidemiological study to date. It describes mortality and morbidity from major diseases, injuries and risk factors to health at global, national and regional levels.

Examining trends from 1990 to the present and making comparisons across populations enables understanding of the changing health challenges facing people across the world in the 21st century.

The year 2015 marked a pivotal transition period for both global health and global surgery. The focus of the global health and development community transitioned from the Millennium Development Goals (MDGs) to a new set of Sustainable Development Goals (SDGs), commitments to Universal Health Coverage and Reduction of Inequality.

A recent World Health Organization (WHO) study found that more than 90% of deaths from injuries occur in low- and middle-income countries. This is not surprising,

considering that the poorest third of the world's population receives only 3.5% of the surgical operations undertaken worldwide. Indeed, many of these countries lack surgical capacity to treat the injured.[11]

Despite such a surgical imbalance around the world, surgery is still "the neglected stepchild of global health".[13]

At this point we can state that there are some common misperceptions about surgery that are not grounded in truth.

For which, no global funding organization focuses specifically on the provision of surgical care, and none of the major donors are willing to support and acknowledge surgery as an imperative part of global public health.

Before to list the three most important misconception about surgery applied to global health we have to remember that until 2015 however, policy makers and funders had largely ignored the sizeable yet unmet need for surgical care, a treatment required for approximately thirty percent of the global burden of disease (GBD)[14], and this lack of attention has left two-thirds of the world's population without access to surgical services.[15]

First, many people think that surgical care can only address a very limited part of the global burden of diseases and thus is of low priority. In reality, injuries (for example) kill more than five million people worldwide each year, accounting for nearly one out of every ten deaths globally. Moreover, the role of surgical care extends beyond treatment of injuries.

For example, surgery is one of the key elements of primary care, and it is also an essential intervention to limit maternal and child mortality.

In a recent report, WHO estimated that approximately 260,000 deaths worldwide were caused by congenital anomalies and 342,900 deaths were due to maternal mortality.[16]

A significant portion of these deaths could have been avoided by implementing simple, cost-effective surgical care.[17]

Second, there is a common notion that surgical care is too expensive to be implemented as part of public health interventions. However, surgery can be remarkably cost-effective, even in comparison to non-surgical interventions that are commonly implemented as public health measures.

Let's take some examples. The cost per DALY (disability-adjusted life year) of emergency obstetric care at a rural hospital in Bangladesh was US$ 10.93 per DALY averted.[18]

The same measurement for all surgical care services provided by a hospital in Sierra Leone was US$ 32.78/DALY averted.[19] This compares favourably to many other primary

interventions such as vitamin A distribution (US$ 9/DALY averted), acute lower respiratory infection detection and home treatment (US$ 20/DALY averted) or measles immunization (US$ 30/DALY averted).[18] [19]

Third, the focus of the global health community on the issue of surgical imbalance has been largely confined to providing short-term relief through medical missions. While these missions have played and continue to play an important role in providing immediate relief in crisis situations, they cannot substitute for a long-term investment in local health infrastructure and staff training that would allow LMICs to develop their own long-term surgical capacity.[17]

In short, surgery can and should be recognized as an important global health intervention. To achieve this goal, it is critical to improve the local surgical capacity in LMICs.

As Paul Farmer, co-founder of international organization Partners in Health, recently noted, "*global health need not be a competitive race for scarce resources…we can build a coherent movement that comes to include surgery*".[20]

Having ascertained these three fundamental concepts, we can apply our reasoning to the need to include paediatric surgery as an integral part of global health.

For understanding and analysing the impact of our work about cooperation, Global Paediatric Surgery and the needs of the last one in LMICs, we need to ask ourselves some basic conceptual questions, to take as a guide for the discussion and to respond to them with clear criteria.

The questions are:

- *What exactly is the burden of paediatric surgical conditions in LMICs?*
- *What is the unmet surgical need?*
- *What resources are required?*
- *What impact would paediatric surgery have on global health?*
- *How can essential surgical services be integrated into health systems?*

By the most recent 2006 estimate, 11% of the global BoD is secondary to surgical conditions (led by injuries, complications of childbirth, congenital anomalies, and non-communicable diseases) (*Figure 1*) [21]

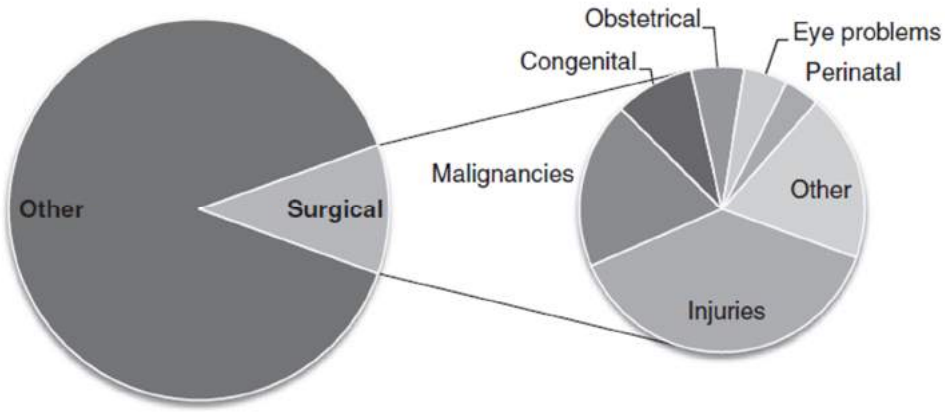


Figure 1. Distribution of causes of total and surgical burden of disease globally. (Ozgediz D, Poenaru D. The burden of pediatric surgical conditions in low and middle income countries:A call to action. J Pediatr Surg. *2012;47(12):2305-2311. doi:10.1016/j.jpedsurg.2012.09.030)*

Almost 40% of the global BoD in LMICs is in children under 15 years of age. In the under-5 group, though deaths from lower respiratory tract infections, malaria, and diarrhoea predominate, some of the remaining categories are impacted by surgical conditions[22]. Over one third of deaths under five years old occur in new-borns, with surgical conditions again playing a role in several categories.

Worldwide, 3%–7% of children are born with congenital anomalies, and 94% of the severe anomalies occur in LMICs. 434,000 deaths also occur from congenital anomalies in children less than 5 years, and 97% of the deaths occur in LMICs.

303,000 new-borns die in the world within 4 weeks of birth every year owing to congenital anomalies.[23]

Congenital anomalies account for a staggering 25.3–38.8 million disability-adjusted life-years (DALYs) worldwide.[23]

However about injuries, there is growing evidence that childhood surgical conditions, especially injuries, are common in developing countries and that poor care results in significant numbers of deaths and cases of disability. [24]

This phenomenon is associated with the habits and risks related to rural life and the presence of armed conflicts in the aforementioned countries as specified in the premise. We will speak especially about burns issues.

Cancer is a leading cause of death for children and adolescents around the world and approximately 300,000 children aged 0 to 19 years old are diagnosed with cancer each year.

The most common categories of childhood cancers include leukemias, brain cancers, lymphomas and solid tumours, such as neuroblastoma and Wilms tumour.

In high-income countries more than 80% of children with cancer are cured, also due to surgical treatments and medical treatments, but in many LMICs only about 20% are cured.
Surgical infections pose another threat to African children. Abscesses, pyomyositis, necrotic fasciitis and osteomyelitis are common in tropical regions of Africa, and their increased incidence is most probably related to malnutrition or immunosuppression associated with parasitic infections.
Surgical infections, particularly chronic osteomyelitis, are a significant burden on health services. At the main government referral hospital in Banjul, for example, osteomyelitis accounted for 7.8% of paediatric surgical admissions and 15.4% of total inpatient days.
The number of hospital days taken up by osteomyelitis was second only to that for burns.[25]
Congenital anomalies constitute a major cause of infant mortality, and patients that survive often live with disabilities that continue into adulthood.
Approximately 3% of live births are associated with some kind of birth defect.
Findings from the Global Burden of Diseases, Injuries and Risk Factors Study (GBD) 2010 suggest that 302,000 infants die from causes attributable to congenital anomalies (6% of all infant deaths), 96% of which occur in LMICs.[26]
About congenital anomalies we can bring as an example, the top ten congenital anomalies in paediatric surgery at *Black Lion Hospital,* Addis Ababa University, Ethiopia (analysed during the period from 2012 to 2017).
Anorectal malformation accounted 8.9% of cases followed by Hirschprung desease (5.8%), hypospadia (4.4%), infantile hypertrophic pyloric stenosis-IHPS (2.6%), undescended testis (2.7%), esophageal atresia-EA with or without tracheoesophageal fistula-TEF (2.6%), persistent processus vaginalis-PPV (2.3%), congenital obstructing posterior urethral membranes-COPUM and posterior urethral valves-PUV (2.2%), congenital abdominal wall defects (1.3%), bladder exstrophy epispadia complex (1.0%).[27]
We must remember that clefts (lip and palate) constitute the major burden of congenital anomalies (with congenital heart anomalies; and neural tube defects).See treatment of lip and palate cleft for watching the percentage (Chapter n. 2.1).

To understand the weight of children's correctable surgical conditions, in a study conducted in a large refugees camp in Kenya[28], the wide variety of surgical conditions, both congenital and acquired reflects a population virtually devoid of previous access to surgical care. Thus, it is expected that most, if not all, fatal conditions have died, while nonfatal conditions generally survived, first presenting for care at whichever age refugees

reached the camp health care system. This extreme scenario virtually transformed urgent paediatric surgical conditions into chronic elective disabilities (as witnessed by teenagers and even adults with unrepaired open bladder exstrophy, cleft lip, or recto-vestibular fistula).[12]

Capacity to do research in many LMIC settings is limited by lack of time, training and funding, as well as need to focus on other priorities such as direct care delivery. United Nations Educational, Scientific, and Cultural Organization (UNESCO) estimates that only 2.2% of the world's researchers are in Africa and 3.5% are in Latin America and the Caribbean compared to 21.9% in North America and 29.5% in Europe.[29] In addition, funding flows for global health research in general are small, and funding flows to global surgery research are even smaller and declining.[14 30]

Surgery research accounts for only 4.1% of all global health research activity, despite the fact that surgical conditions constitute one third of the global burden of disease and surgical intervention is needed across all GBD subcategories.[14 31]

Although simple estimates of the burden of paediatric surgical conditions are difficult; existing data indicate a large burden of surgical conditions in children and a high unmet need for surgical care.

The burden of surgical conditions can be divided into two main categories:

- *avertable burden*
- *non-avertable burden.*

Avertable burden (conditions that can be prevented or corrected with surgical care) can be further divided into met need (averted DALYs) and unmet need (avertable DALYs).[32] (*Figure 2)*

Non-avertable burden refers to conditions that cannot currently be averted with surgery, but which may be reduced with other interventions such as prevention or future surgical innovations.

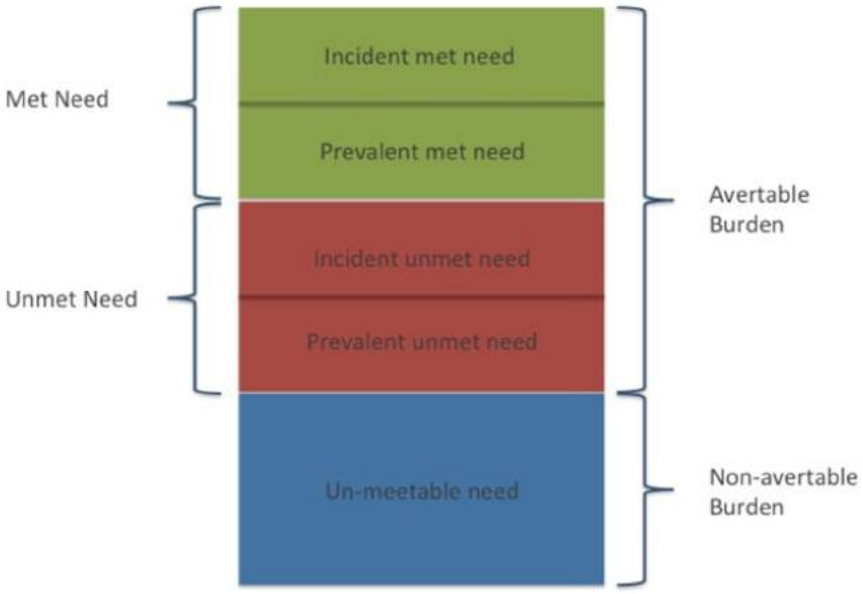


Figure 2. Components of the burden of surgical disease (Adapted from Poenaru D, Ozgediz D, Gosselin RA. Burden, need, or backlog: A call for improved metrics for the global burden of surgical disease. Int J Surg. *2014)*

It is also very important to assess the intervention timeliness. In fact, Burden of disease (BoD) measures should (but do not currently) also capture death and disability suffered by children before they receive treatment, or the delayed BoD.

The disability a child suffers from living for years with an untreated surgical condition (such as compromised nutrition and development due to an untreated cleft palate, social isolation due to a stoma following partial treatment of Hirschsprung's disease, or mobility impairment due to an untreated femur fracture) is substantial and untreated paediatric surgical conditions are widespread.

For example, it is estimated the wait time in Kenya for a posterior sagittal anorectoplasty is 74 months and 72 months for an orchidopexy.[33] Even if treatment is finally received for these conditions, outcomes tend to be much worse for children receiving delayed care compared to those who receive timely intervention.[35]

The delayed access to surgery causing this backlog generates a unique portion of the unmet surgical need that has not been previously characterized and corresponds to the years each child lives with her/his disabling condition until surgical treatment is offered.[12]

The majority of the non-avertable burden of surgical conditions in all age groups is due to injuries. Injuries are a leading cause of death and disability among children in all regions of the world.[35]

Research on how to best reduce this non-avertable burden of surgical conditions (including prevention strategies, improved care delivery methods, and surgical innovations for resource-limited Settings) can help identify approaches to decrease child morbidity and mortality.[36]

When we speak about strategies for addressing the avertable burden of surgical conditions in children in LMICs we need to say that one of the most pressing needs surrounding the surgical care of children in those countries is identifying how surgical and anaesthesiological care can best be implemented in regions where needs are greatest, but health systems are least developed. Implementation efforts can make the most impact when all dimensions of care delivery and all barriers a patient may face in receiving care are considered. Healthcare delivery requires *staff, stuff, space, and systems* (the 4Ss).[15]

The presence of all these elements is necessary to avert delays in care which are associated with poor surgical outcomes.

Consequences of deficiencies in components needed for paediatric Surgery (such as a large number of sick children, great backlog in cases resulting in advanced pathology, high mortality and poor outcomes) are also common.[37]

In contrast to the volume of literature assessing this capacity *problem*, studies looking at *solutions* are scare; there are very few published examples of well-functioning surgical services for children in LMICs.[36]

Another point to treat is that there is a currently a large deficiency in volume and a maldistribution of the surgical workforce in many regions of the world. Recent estimates cite a shortage of over 1 million surgical, anaesthetic and obstetric (SAO) providers across 136 LMICs.[14]

In addition to a volume shortage of surgical providers, there is also a gross inequity in their distribution. Only 12% of the specialist surgical workforce works in Africa and Southeast Asia, which is home to 33% of the world's population.[14]

In LMICs, there is a severe shortage of surgeons with as few as one paediatric surgeon for nearly 6,000,000 children compared with one paediatric surgeon for every 100,000 children in the USA.

This inequity in workface distribution is evident if we observe the fallowed table (*Table 2*) which includes data from COSECSA region.

This deficit is especially pronounced in rural areas.

COUNTRY	FEMALE	MALE	TOTAL	POPULATION
Ethiopia	4	7	11	102.4 million
Kenya	1	16	17	48.46 million
Malawi	1	2	3	18 million
Mozambique	0	2	2	30 million
Rwanda	0	1	1	11.92 million
Sud Sudan	0	0	0	12.23 million
Tanzania	3	2	5	55.57 million
Uganda	3	5	8	40 million
Zambia	0	2	2	16 million
Zimbabwe	0	3	3	16 million
Burundi	0	0	0	12.23 million
Namibia	0	0	0	2.59 million
TOTAL	13	39	52	365.4 million

Table 2. Distribution of Paediatric Surgeons in COSECSA region (Adapted from Holmer H SM, Riesel JN, Meara JG, Hagander L. Towards closing the gap of the global surgeon, anaesthesiologist and obstetrician workforce: thresholds and projections towards 2030).

Some structured training programs in paediatric surgery do exist in LMICs including options in India, South Africa, Egypt and Nigeria and both the *West African College of Surgeons* (*WACS*) and the *College of Surgeons of East, Central and Southern Africa* (*COSECSA*) have certification and training options, across all LMICs, but paediatric surgical and anaesthesia training programs are quite limited in number, especially considering the current shortage of providers.[38]

Although optimal resources for children's surgical care to improve outcomes have been outlined for HICs,[39] these guidelines cannot practically be applied to many low-resource settings and similar broad guidelines for LMICs do not exist.

For this reason, there is still a lot of work to do for understanding all aspects of Global Paediatric surgery.

Moreover, research is needed to better define how all partnerships – whether they be with HIC partners, LIC leaders, NGOs, different care delivery sectors, researchers or funding organizations - can best help meet local needs and strengthen surgical systems and care delivery efforts.

Investigations needed into what current partnership is doing, that concern: (1) factors that allow better results, also in terms of impact on children and local health systems; (2) methods for guiding coordination and regulation of efforts.[36]

There are several models of care delivery in LMICs, including faith-based missions, short-term surgical trips, surgical camps, and mobile health but the most common models are short-term.

While short-term models address immediate needs and provide vital opportunities for education and training, long-term models of partnership building and incorporating paediatric surgical care into national healthcare plans will increase sustainability and capacity building.

At the heart of global paediatric surgery research is a desire that no child should suffer the consequences of surgical conditions for which effective treatments can be provided. Improved understanding of the epidemiology of paediatric surgical disease; its impact on individuals, families, communities, and countries; the availability and accessibility of safe surgical and anaesthesia care; the comparative effectiveness of models for scaling-up surgical care; the economic consequences of inaction; and the complementarity between surgical care, health system strengthening and other global health movements is critical.[36]

In light of above and of the fact that without robust data on the burden of surgical conditions in children, areas of greatest need are not known, we want to describe, analyse and understand some missions for carrying an active contribution to research.

1.1. GLOBAL PAEDIATRIC SURGERY EXPERIENCES OF PAEDIATRIC SURGERY DEPARTMENT OF FERRARA

As already mentioned, voluntary activities and cooperation in LMICs, particularly in the health sector, represent an actual reality that is extremely widespread and acknowledge by International Cooperation.

Italian Paediatric Surgery is particularly active in this sector, both in terms of organization and participation in surgical missions, and in terms of broader international cooperation, also including fundraising activities, supply of technical and professional support, training contribution, welcoming patients in their own country according to the various surgical procedures.

The voluntary surgical activity of the Paediatric Surgery Department of Ferrara for children in LMICs began in 1995, from an idea of Dr. Paolo Georgacopulo and followed later from Dr. Andrea Franchella.

Ferrara's Pediatric Department has participated in different missions in non-EU countries by carrying out its activities for example in Guatemala, Ecuador, Kenya, Tanzanian.

The purpose of the missions was to perform the surgical activity by conforming as much as possible with the cultural context of the host country, also trying to involve local professionals.

The projects have always been characterized by the desire to establish a relationship of cultural exchange avoiding colonialist attitudes, these are mostly educational objectives, simple contributions to the professional growth of structures and personnel blocked by poverty. The activity of medical and nursing staff is completely voluntary, the organization of the mission provides for complete self-sufficiency with regard to health and medicinal materials; everything that is not used is then left on the facility.

The training of local staff adds a good incentive to the correct future use of materials to avoid waste.

The prevailing support, at the beginning of the experience, came from private funds, mainly from the Foundation for Research in Pediatric Surgery "R. Melotti", which financed the first stays of pediatric surgical teams in Central American countries, jointly with Rotary International and WOSPEC (World Organization of Pediatric Surgery for Emerging Countries).

Over the years there has been a progressive evolution of the humanitarian experiences ended in the transition from simple surgical missions to the realization of real health cooperation projects with a particular attention to improving aspects related to quality and implementation of training courses.

The surgical missions are organized by the Pediatric Surgery Department with the collaboration of the *Azienda Ospedaliero-Universitaria* of Ferrara with regard to the supply of medical stuff and drugs.

The team is always made up of professional figures such as:

- One Leader Pediatric Surgeon
- A second operator (another pediatric surgeon or a junior pediatric surgeon in training)
- Two anaesthesiologists experienced in paediatric anaesthesia and resuscitation
- One experienced nurse in paediatric anaesthesia

Each professional figure involved in a humanitarian mission is assigned different tasks:

- *The surgeon*. The cornerstone of his activity is to open an outpatient clinic, to evaluate case by case without ever forgetting that the healthcare facilities he uses guarantee very limited post-operative hospitalization and the possibility of using a resuscitation department in case of major surgery. To perform surgery as safely as possible for the reasons mentioned above. To follow up the patient, especially in the postoperative period, trying not to leave critical situations behind at the end of the planned mission period.
- The *anaesthesiologist-resucitator*. He must carefully evaluate the patients to undergo surgery and show extreme flexibility in his profession because there are often no obvious materials and machinery on facility. The cooperation and dialogue between surgeon and anesthesiologist are very important a comprehensive patient evaluation.
- The *nursing staff*. The same considerations as above apply, versatility and the ability to communicate and dialogue with patients are fundamental.

All professional figures must integrate with the local corresponding figures: cultural exchange is the basis of the purpose of a mission.

Before departure, there is a preparation phase, during which the surgical and anaesthesiologic material and the necessary drugs for antibiotic prophylaxis, peri-operative pain control and anaesthesia are prepared.
Part of the material (in particular, the material for dressings, gloves, surgical masks, topical products) in some countries, may be available on site.
Missions have an average duration of 20 days.
The local population is informed of the arrival of the team a few weeks before, through the work of the on-site staff.
The work of each mission is organized as follows:

- In the first 2-3 days an outpatient activity is carried out by a surgeon and an anaesthesiologist, in which patients that need surgery are selected. On the same occasion, the patient is therefore evaluated by the anaesthesiologist.
- If necessary, blood sampling is also carried out or pre-operative therapies (for example antibiotic prophylaxis) are prescribed.
- Finally, all the rules relating to pre-operative preparation (as fasting and presentation time on the set day) are communicated . In some particular situations, if the family resides very far from the facility and it does not have easy means of transport, immediate hospitalization of the child may be decided and therefore placed among the first in the surgery list.
- After the selection of patients, the operative sessions begin; the work is organized in time slots from Monday to Friday, with extreme variability due to daily organization problems that are obviously difficult to prevent.
- At the end of the operating sessions the patients are re-evaluated, the medications are made and any discharge for the following days is organized.

1.1.1. The birth of the non-profit organization (ONLUS) "*Chirurgo e Bambino onlus*" (Surgeon and Child)

The non-profit organization "*Chirurgo e Bambino Onlus"* was born in July 2003 as a response to humanitarian reasons in the health field expressed by the Ferrara group of

doctors working in the Pediatric Surgery Department – lead by Dr. Andrea Franchella – of the *Azienda Ospedaliero-Universitaria* of Ferrara.

Convinced of the assistance emergency of poor countries, the Paediatric Surgery Department wanted to coagulate aspirations and future healthcare aid projects by establishing, the non-profit organization, which, by statute, aims to achieve development programs and support for paediatric surgery, not only in Italy, but especially in developing countries.

The association is a non-profit organization and pursues exclusively socially useful purposes in the field of Paediatric Surgery through activities in the following sectors:

- health care
- social care
- promotion and training in the field of Paediatric Surgery and in the assistance of paediatric surgical patients, in Italy and abroad
- scientific research

One of Organization aims, during its surgical missions, is to promote theorical and practical training on site of the healthcare personnel who work there and to provide, as far as possible, also technological support.

The organization also proposes to organize annual solidarity initiatives for fundraising, to be assigned to the objectives which it pursues, as well as scientific initiatives to spread its business and encourage the exchange of ideas and experiences in the field of health cooperation in paediatric surgery.

Over time, various collaborations have started with other NGOs.

The Organization then collaborated with "*Operation Smile Italy*" (2005-2006) in Armenia and Georgia and with "*Smile Train Italy*" (2007-2010) in Bangladesh, Yemen, Ethiopia, Ivory Coast and Benin with projects dedicated to the treatment of lip and palatine cleft.

From 2007 to 2009, it developed with the NGO *"A.D.I.D."* a project for the training of paediatric healthcare personnel in Mauritania.

Since 2010 an important collaboration has been underway with the "*Francesca Rava NPH Italy Foundation*" for a training project in Paediatric Surgery at the *S. Damien Hospital* in Haiti.

Since 2011, a similar project has been undertaken with the "*Ruvuma Onlus*" association at the *Mbweni Hospital* in Tanzania.

"*Chirurgo e Bambino onlus*" has recently carried out a health cooperation project with the Paediatric Clinic *São José em Bor* in Guinea Bissau for the creation of a Paediatric Surgery service dedicated in particular to the treatment of congenital malformations of the newborn infants.

Figure 3. Non-profit organization "Chirurgo e Bambino onlus" Logo

1.2. SURGERY MISSIONS

1.2.1. Siberia (Russia) -2005

In August 2005 (from 22nd to 27th), the Pediatric Surgery Department of Ferrara has joined a humanitarian mission in collaboration with "*Operation Smile Italia*", a global organization that deals with the primary and secondary treatment of cleft lip and palate in developing countries.

This mission took place in Novosibirsk -Siberia at the *Novosibirsk Children Clinical Emergency Hospital*.

In that occasion, 62 surgical operations were carried out during the mission.

1.2.2. Armenia (Asia) -2006

In August 2006 (from 5th to 12th), again in collaboration with "*Operation Smile Italia*", a mission took place in Armenia with the same characteristics as the Siberian humanitarian mission.

The mission was aimed mainly at the treatment of cleft lip and palate of young patients and it was also aimed at creating a training course dedicated to cleft lip and palate.

The humanitarian mission took place in the capital Yerevan and it ran at the *Pediatric Hospital.*

On that occasion, 20 surgical operations were performed.

1.2.3. Kenya (Africa) -2004

Matiri's mission began in 1957, and great strides have been made since its founding.

However, it is not possible to quantify the surgical missions numerically at the *Saint Orsola Hospital*, since they have often been long-term missions (lasting 3-6 months), which were attended by doctors in specialist training from Paediatric Surgery Department of Ferrara, during which 292 surgeries were performed.

We will talk specifically about an experience that took place from October 2003 to May 2004 (so a long-term surgical mission), in which the prevalence of surgical interventions concerned the treatment of burns and scarring.

Having identified this priority problem, it was decided to create a dedicated burns area.

This area has a semi-intensive type patient room, equipped with cardiac monitoring equipment. There is also a room for surgical brushing and dressing for exclusive burns use, equipped with a tub for making antiseptic baths. There is also a laboratory where it is possible to dose the electrolytes and the basic parameters. For surgical treatment, an electric dermatome complete with accessories and a skin masher (for the expansion of the skin grafts) have also been made available.

1.2.4. Mauritania (Africa) 2007-2009

The goal was to analyse the country's health and training needs, while assessing technological shortcomings, to meet the primary health needs and plan the development of Paediatric Surgery in the country.

The Pediatric Surgery Department of Ferrara through "*Chirurgo e Bambino Onlus*" participated in the hospital's activities by carrying out multiple surgical missions, in which about 300 surgical interventions were carried out. Efforts were also made to guarantee continuity of care with regard to the treatment of surgical and pediatric cases.

The missions were organized with the collaboration of the NGO *"A.D.I.D."* (Mauritania) and were carried out at:

- *Kaédi*. The hospital is equipped for adults, but not for children, there is only a paediatrician, so there is no possibility of dedicated hospitalizations.

- *Nouadhibou*. The hospital was founded in 2002 by the will of a Spanish NGO, which still serves it today. It has been active since 2004 and it has equipped with operating rooms and there is a paediatric department.

1.2.5. Makallè-Ethiopia (Africa) -2009

The mission was mainly addressed to the treatment of cleft lip and palate and it was carried out in collaboration with *Smile train Italia.*

The headquarters for the project realization was the *General Hospital* of Makallè that hosted the mission.

1.2.6. Tanzania (Africa) 2007-2020

The missions were carried out in Mbweni and Itigi.

Mbweni hospital is located in the village from which it takes its name, more or less 50 km from the city of Dar Es Salaam, along the coast of Tanzania. The current structure was born 13 years ago as a dispensary (Health Center) at the behest of the Organization "*Ruvuma ONLUS*". The administrative and health management has been entrusted for some years to the Indian religious order "*Daugthers of Immaculate Mary*" which has transformed the facility into a hospital.

The Pediatric Surgery Department of Ferrara through the non-profit organization *Chirurgo e Bambino* participated in the hospital's activities by carrying out two or three surgical missions per year, trying to guarantee continuity of care and treatment of pediatric surgical cases.

From 2004 to 2008, a total of 5 missions were organized, in order to plan and treat patients with cleft lip and palate and post-burn scar retractions.

In 2008, three missions were carried out: two of them (on March and on April) for the treatment of cicatricial retractions, the third one (on May), in collaboration with the non-profit organization "*Smile Train Italia*", for the treatment of patients with cleft lip and palate.

After these surgery missions, the collaboration with "*Smile Train Italia*" continued until 2015.

Itigi is a small village in the center of Tanzania where the "*Fathers of the Precious Blood*" built the *St. Gaspar referral hospital* (a missionary hospital) where two missions (2014-

2015) were carried out in collaboration with the *Children's Pediatric Hospital Bambino Gesù* of Rome.

1.2.7. Benin (Africa) 2011

The organization "*Smile Train Italia*", through the realization of an agreement with the Health Authorities of the Republic of Benin, proposed to intervene, in collaboration with local doctors, for patients with craniofacial malformations as well as other pathologies such as sequelae burns and trauma, creating surgical missions, participating in the training and development of local professionals and developing prevention programs. With reference to the operative part of the agreement concluded between the Republic of Benin and Italy in public health, the Ministry agreed to provide the logistic support to the organization Smile Train Italia.

Smile Train Italia adopted a multidisciplinary approach based on teamwork. Each group of volunteers was made up of surgeons (specialized in plastic and reconstructive surgery), anaesthesiologists, paediatricians (specialized in intensive paediatric care) and nurses. The objective of the mission was to allow the Republic of Benin to stand on its own in this area. To carry out such a project, *Smile Train Italia*, in collaboration with the Ministry organized training courses in management of all health professionals in Benin with the objective of creating an organization chart for prevention, pre-operative, surgical and post-operative care of patients.

The first objective of the mission was to establish a collaboration with the Benin Ministry of Health by developing concrete strategies to medium and long term to strengthen local skills in the field of health.

There were also a collaboration with "*The Resurrection*" NGO that is an organization that aims to carry out health activities giving assistance to disabled children, victims of facial malformations, and treating after-effects accidents, burns, meningitis, and polio. The NGOs together intended to provide training for specialists for the effective care of disabled people in local hospitals.

The first mission took place on 2011. Before the arrival of the Italian volunteers, the Beninese Ministry of Health carried out a national campaign to locate small patients. The team made up of 10 volunteers (plastic surgeons, anaesthetists, paediatricians, nurses and coordinator brought all the equipment (instruments and drugs) necessary for the accomplishment of the mission. 40 patients were examined and 22 were operated on.

The Italian team worked in cooperation with doctors and nurses of the hospital to prepare as well future collaboration with the Cotonou National University Hospital Centre (CNHU): the volunteers worked closely in collaboration with CNHU staff often going over their scheduled hours.

The organization noted that the number of consultations was relatively small; this is probably due to logistic reasons and means of displacement of children living in remote areas.

1.2.8. Guinea Bissau (Africa) 2017-2019

Is it possible to describe this mission as a long-term model of partnership.

Three missions were organized at the *São José em Bor* pediatric hospital in Bissau, mainly dedicated to a training project in Paediatric Plastic Surgery. The hospital was founded by Father Ermanno Battisti, *PIME* missionary.

In 2010, the operating block was created with an operating theatre and equipment comparable to European standards, mainly thanks to the non-profit organization "*Poliambulanza of Brescia*".

At the organization level, professional integration was put in the foreground. Training was and is the priority of project, together whith innovation and change, especially the cultural change of healthcare personnel.

São José em Bor hospital has reached a satisfactory organizational and welcoming level; it has a house that can accommodate eight people in four rooms each with an en suite bathroom. Staff is able to take responsibility for coordination.

The structure sufficiently equipped from a technical point of view and with healthcare personnel already with some experience in the discipline or sector covered by the training cycle, it is a place of support addressed not only to internal staff but also to the training of staff from other Guinean-Bissau structures to create a favorable environment for the development of public health.

The purpose of the coordination is to guarantee and certify high scientific training for doctors and nurses from Guinea-Bissau and at the same time create local agreements to better fit into the training programs, mutually and officially recognized.

In this context, the role of the local University with which the *Bor Hospital* already collaborates can be important, providing teachers, training courses, and offering students the possibility of internships within the hospital.

The project involves the execution of scheduled surgical interventions connected to theorical and practical courses lasting two or three weeks, preferably performed by several teachers at the same time. Theorical lessons and individual meetings between teachers and students are carried out in order to make the training course as profitable as possible. Practical activities are also foreseen such as the participation of learners in preordained surgical interventions, which in some cases will see students and/or local doctors as first operators also coming from hospitals operating in the area.

It is also envisaged to identify professionals capable of holding training courses, on site at various levels, (for socio-health actors, doctors, nurses, social workers etc.) lasting several months for several years. You can focus on retired professionals or who have the time and willingness to guarantee long enough periods to implement the multi-year project.

It was fundamental the collaboration between the head of the Pediatric Surgery Department, Doctor Dionisio Cumbà, *Chirurgo e Bambino onlus* end the Pediatric Surgery Department of Ferrara.

1.3. GLOBAL PAEDIATRIC SURGERY EXPERIENCE OF *"FES FUNDACIO'"* and *"IMF SOLIDARI"*

From October 2004, one junior paediatric surgeon of Ferrara moved to Barcelona (Spain) and began to collaborate with Dr. Francisco José Parri Ferrandis both in *San Juan de Dios Hospital* and in the humanitarian projects.

Moreover, in last three years, *"FES Fundació"* and *"Chirurgo e Bambino onlus"* took turns in carrying out some surgical missions in Guinea Bissau.

So, with Dr. Parri permission, we report the results of some of Spanish surgical missions.

Institut de Malformaciones Faciales Dr. Parri (IMF) is a Spanish organization founded by Dr. Francisco José Parri Ferrandis, a paediatric surgeon from Barcelona.

Institut de Malformaciones Faciales is a professional and multidisciplinary humanitarian team made up of paediatric plastic surgeons paediatric anaesthesiologists, and nurses with extensive experience in the treatment and management of patients with maxillofacial malformations.

It is also made up of experts from different medical specialties related to facial malformations and who collaborate all together, such as paediatricians, speech therapists,

psychologists, orthodontists, geneticists, needed for pursuing the important multidisciplinary treatment of pathology

The institute motto is "*every child with a treatable facial malformation deserves treatment wherever he is*", so the children, whether they are from Spain or elsewhere, are the object of their effort and continued training.

For all these reasons Dr. Parri decided also to create the non-profit organization "*IMF Solidari*", which move to LMICs and which is made up of doctors, from different specialties and countries, who work together in solidarity tasks and offer their experience and knowledge to children with facial malformations who do not have the possibility of receiving appropriate treatment, either because of the poverty in which they live or because of the lack of specialists.

IMF Solidari has the capacity and experience (also acquired by a collaboration with *Vicente Ferrer Foundation* in Anantapur, India) to serve patients, but above all to train doctors in those treatments.

The organization achieve also to teach, local professional figures interested in training from the same country, and if it is possible from the region, since their professional loyalty to the hospital centre and the geographical area are enhanced by continuing the project. The objective it also to allow a follow-up of the cases, returning the following year and continuing the training and treatment of new and increasingly complex pathologies.

FES Fundació is a Spanish non-profit organization that was born in parallel with *IMF Solidari* with which there is a strong collaboration.

The Principles are to provide the human, technical, economic, and material resources to carry it out wherever there is a need.

Moreover is considered fundamental to promote and to facilitate specific training for professional figures in all fields related to orofacial malformation in geographic regions with limited development and resources in this area, in the form of grants or scholarships to train at the organization.

Facilitate continuous training in the form of stays, attendance at courses and conferences of professionals linked to the foundation and promote the transmission of knowledge among professionals, either by participating in or organizing courses or conferences.

Promote clinical and experimental research in orofacial malformations.

Facilitate the development of procedures, techniques, processes, materials or instruments that help achieve the main foundational goal.

For *FES Fundació* is crucial to collaborate with other foundations, organizations or entities with similar purposes.

We will describe and analyse in detail some missions that took part in Ethiopia and Peru in collaboration with *"FES Fundació"*.

Figure 4. FES Fundaciò Logo.

1.3.1. Ethiopia (Africa) 2009

Two surgical missions were performed in Ethiopia, at the *Gambo Rural Hospital*, 6 hours south of Addis Ababa. The Organization has learned things from previous experiences: they travelled with a larger team, the stay was longer and it was made the necessary adaptations in equipment and material.

The hospital has sufficient means and the team, composed of ten people, operated on children with cleft lip and palate and many sequelae of burns.

The consequences of burns prioritize needs and the organization has brought an electric dermatome to perform skin grafts. It was part of the teaching objective of the projects.

As in every mission, one of the objectives is to see the results. In children with cleft lip or palate, a good intervention is final and will not need any further control but in the aftermath of burns, follow-up and rehabilitation are very important.

Ten people composed the team.

The collaboration of religious from different missions has been essential, for collecting and screening patients from very remote areas.

1.3.2. Peru (America) 2011

The *IMF* Solidari project in Trujillo (Peru) in 2011 took part at the *Hospital Belén* of the city where the consultations, interventions and admissions have been made. It is a charitable hospital, well endowed with resources, which has offered its facilities (with two operating rooms) and services characterized by a strong collaboration with its director, Dr Miguel Angulo.

A team of eight people visited 55 children, basically with a cleft lip and palate in different treatment states (not operated, operated on one hand and others with sequelae) and also some children with paediatric plastic surgery problems.

The patients were from families with low economic resources and the majority of rural areas far from the city.

On Sunday afternoon, an intense diagnostic visit pass, classification and preoperative evaluation allowed the team to plan the surgical programs for the whole week and it start working on Monday at maximum efficiency.

Of the 55 patients visited, 26 met the conditions to be operated under general anaesthesia. Ten from primary lip or palate surgery, nine from secondary lip or palate surgery or sequelae, and seven from other facial plastic surgeries. 12 children have been left pending intervention. His general or analytical state, or age, did not recommend surgery on this trip.

We have to remember that generally in Peru, there is a paradox that few people have social security, and even if they undergo surgery in a charity hospital, they have to pay for or provide all the disposable materials and medicines needed for their operation.

To solve this important problem, the Organization opened an account in the hospital pharmacy and every day we made the order of what we would need for the following day surgical operations.

During this surgery mission, this important economic expense has been covered by the Peruvian Doctors of Barcelona Organization *AMEPEBA* (*Asociación de Médicos Peruanos de Barcelona*) represented by Dr Carlos Ganoza.

There was also a strong support from *IDEBISEP* (Institute for the Development and Socio-Economic Well-being of Peru), represented by attorney Jenny Ortiz.

A crowded press conference and a radio program allowed the project to be broadcast, news on television and in the local press to be generated, and several patients to visit.

1.3.3. Peru (America) 2012

The surgery mission in 2012 had two destinations in Peru: the city of Trujillo, on the north coast, where the team worked during the previous mission, and a new destination in the city of Pucallpa, in the central Amazon jungle.

The *Benéfico Belén Hospital* in Trujillo was again the team's headquarters for consultations, surgeries and hospitalization. The patients received free treatment and if any medication or material was needed that the team did not have, it was bought from the hospital pharmacy.

The surgery mission has received the personal support of the Freedom Region president and the authorities responsible for health.

The institutional support was good, but the Organization has longed for the street work of the local NGO *IDEBISEP*, which the year before sought out and brought many patients by the hand.

During the first week the team worked on two operating rooms in the afternoon-evening hours, so as not to alter the daily work of the operating rooms. Many days the team finished around 23h.

The second week, half of the team continued in Trujillo and half travelled to the *Hospital Amazónico de Yarinacocha*. It is a rural hospital that covers a huge area where children with clefts are unable to receive treatment for their malformation.

1.3.4. Peru (America) 2013

The Peru surgery mission in 2013, has pivoted on two axes: paediatric surgery and dentistry.

Eight professionals from the FES Fundació worked at the *Tony Molleapaza Rojas Children's Hospital* in Arequipa.

1.3.5. Peru (America) 2014

It was the tenth solidarity project of the FES Fundació, carried out in 2014 in Arequipa (Peru). That year it was combined surgery for children with cleft lip and palate and dentistry in disabled children.

The surgery team has visited 55 patients, of whom 26 have been operated: two with skin lesions and 24 clefts, which is the "target" patient.

In 17 cases the surgery was primary (five lips and 12 palates) and in 7 it was secondary (one lip, three palates and three pharyngoplasties). Several of the patients had undergone surgery the previous year for the lip and this year for the palate and it was possible to verify the good evolution and the good result in most of them.

That year *Fes **Fundació*** took another step: hospital solidarity dentistry. It allows to take care of patients in the dental chair and, also in the operating room, either under sedation or under general anaesthesia.

More than 150 patients have been seen and treated in consultation (half of them disabled) and 14 in the operating room, among those treated under sedation and general anaesthesia.

It is evident the importance of the anaesthesiologists, who must manage a difficult patient with the minimum anaesthetic needs, so the dentists perform the maximum possible procedures.

2. SURGERY

In this chapter we analyse the most common surgical treatments performed during the humanitarian missions. in LMICs.

2.1. TREATMENT of CLEFT LIP and PALATE

In 1981, Whitaker et al introduced a simple classification system to help conceptualize the vast array of congenital pathology involving the craniofacial region.[40] Based on anatomy, etiology, and current treatment principles, most craniofacial anomalies can be classified into one of four categories: clefts, synostoses, atrophy-hypoplasia, or hypertrophy-hyperplasia-neoplasia.

As previously analysed, Orofacial clefting is the most common birth defect in the world. Cleft lip, with or without cleft palate (CL/P), occurs spontaneously among Caucasian populations in approximately 1 out of every 1000 births. It is over twice as common (1 in 450) among Asians and Native Americans and half as common (1 in 2000) in African Americans. There is a predilection among males, who are twice as likely to be affected as females. Left-sided cleft lip is twice as common as right and nine times as common as bilateral. Of patients born with CL/P, 29% have associated anomalies, which can range from minor physical differences to major organ involvement. While a family history of CL/P remains the strongest known predictive factor, other extrinsic risk factors include maternal smoking or early exposure to the anticonvulsant drug phenytoin.[41]

Epidemiologically, isolated cleft palate (CP) appears to be distinctly different from CL/P. CP occurs in 1 of every 2000 live births. It is twice as common in females, and it demonstrates no racial or ethnic preponderance. It is very important to remember that nearly half of patients with isolated CP have a diagnosable syndrome and additional congenital anomalies. Evaluation by a geneticist is therefore indicated in all babies born with isolated CP. Like CL/P, isolated CP is multifactorial. Known environmental risk factors include maternal smoking or alcohol consumption, folate deficiency, use of steroids or anticonvulsant medications, or retinoid (vitamin A) excess.

Some familial patterns of orofacial clefting have been linked to specific genetic mutations (i.e. Van der Woude syndrome, an autosomal dominant form of CL/P associated with lower lip pits, is caused by an *IRF6* gene mutation).[42] Stickler syndrome should be

suspected in patients with isolated CP, with associated eye defects, sensorineural hearing loss, and joint abnormalities. This constellation of findings is due to an autosomal dominant mutation in a procollagen gene.

Stickler is also the most common syndrome associated with Pierre-Robin sequence (micrognathia, glossoptosis, and respiratory distress).[43](Fig. n. 5)

These examples help emphasize the importance of early genetic workup for patients in whom a syndrome is suspected.

Figure5. Pierre-Robin sequence. Case from Paediatric Surgery Department of Ferrara.

2.1.1. EMBRYOLOGY OF THE LIP AND PALATE

The “primary palate,” which includes the nostril sill, upper lip, alveolus, and hard palate anterior to the incisive foramen, forms from fusion between the medial nasal and maxillary prominences during weeks 4 through 7 of gestation.[44] [45] Development of the hard palate posterior to the incisive foramen and the soft palate, which are collectively known as the “secondary palate,” occurs during weeks through 12 of gestation. The lateral palatine processes initially hang vertically on either side of the developing tongue. Around week 8, these palatal shelves rotate into a horizontal orientation, bringing their free edges into close proximity with the nasal septum. Midline fusion then commences, proceeding posteriorly from the incisive foramen (Fig. n. 6).[42]

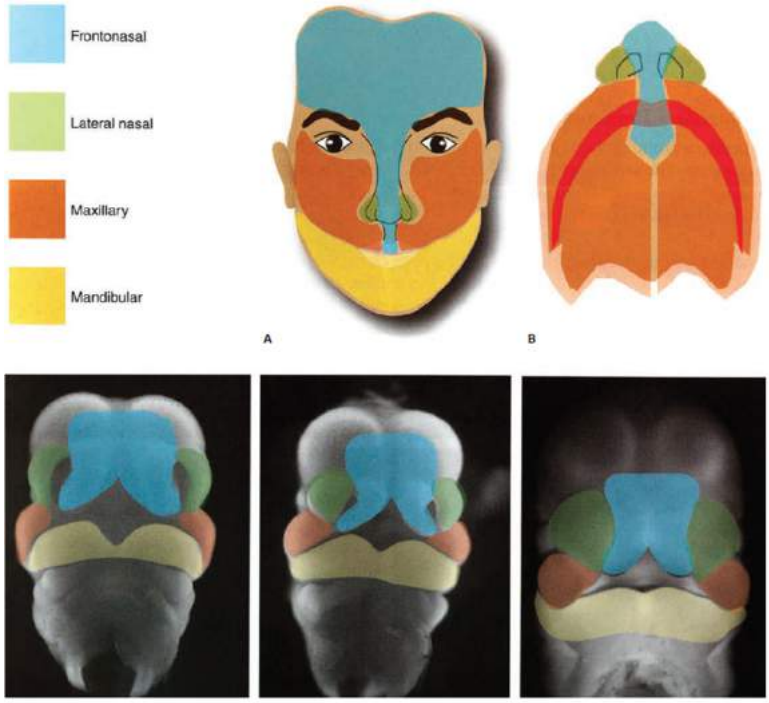


Figure 6. Facial prominences and their contributions to facial development. Cleft lip results from failure of fusion between maxillary.

2.1.2. NORMAL AND CLEFT ANATOMY

There are several key defining characteristics of the lip that make its surgical repair so challenging.

On the surface, the philtrum of the upper lip is comprised of paired philtral columns and a central philtral dimple.

The white roll passes along the vermilion-cutaneous junction, peaking at the base of the philtral columns and dipping centrally to form Cupid's bow. Deep to the surface, the paired orbicularis oris muscles originate lateral to the oral commissures and encircle the mouth, decussating in the midline and sending off dermal insertions to the philtrum. This intrinsic muscle of the lip provides oral competence and assists with speech production and facial expression. Continuity of the orbicularis oris muscle is disrupted in babies born with a cleft lip. Aberrant muscle insertion into the piriform aperture laterally and the anterior nasal spine medially contributes to the hallmark appearance of cleft lip and nasal deformity (Fig. 7).[44]

Figure 7. Hallmarks of unilateral cleft lip deformity include Hallmarks of unilateral cleft lip deformity include depression of the nasal tip and flaring of the alar base on the cleft side, deviation of the caudal septum and columella toward the noncleft side, and deficient lip height (short philtral column) on the cleft side with cephalad rotation of the cleft side of cupid's bow.

Clefts of the lip can be described as unilateral or bilateral and microform, incomplete, or complete. Microform cleft lip is the most minor variant and may manifest as subtly as a small notch in the vermilion.

An incomplete cleft lip, by definition, requires an intact nasal sill. The term can otherwise be applied to a wide spectrum of anomaly, ranging from a partial cleft of the lip alone (Fig. 8A) to a near-complete cleft of the entire primary palate. A complete cleft lip involves all structures of the primary palate in their entirety, extending through the nasal sill and opening into the anterior nasal floor (Fig. 8B).[44 46]

A B

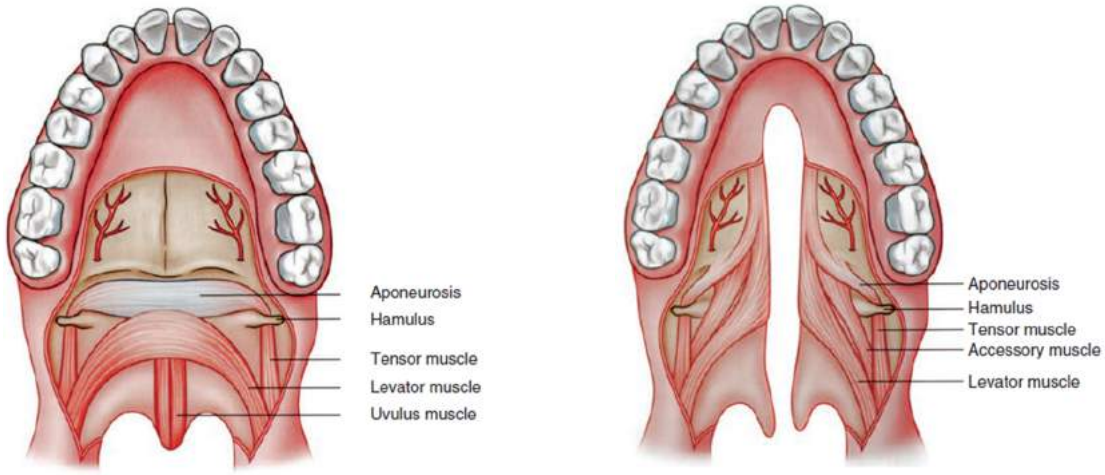
Figure 8. Variations in unilateral cleft lip morphology. Left unilateral incomplete cleft lip.

The normal palate functions primarily as a speech organ, but it is also intimately involved in feeding, swallowing, and breathing. The soft palate, or velum, together with lateral and posterior pharyngeal walls, can be conceptualized as a valve that regulates the passage of air through the nasopharynx. The paired levator veli palatini muscles descend from the cranial base and decussate in the midline to form a sling within the soft palate. This sling acts to elevate the velum against the posterior pharyngeal wall, effectively closing the velopharyngeal port.

In patients with cleft palate, the levator muscles are unable to cross the midline.

Instead, they run parallel to the cleft margin and insert aberrantly into the posterior edge of the hard palate (Fig. 9A,B).[47]

Air is allowed to leak through the nose during attempts to suck or speak. This inability to build negative or positive intraoral pressure makes either task difficult, if not impossible. The tensor veli palatini muscles, which normally function to vent and drain the Eustachian tubes, are also disrupted in cleft anatomy. Eustachian tube dysfunction predisposes patients to frequent bouts of otitis media, which can lead to permanent hearing loss if left untreated.[44]



A B

Figure 9. ***A.*** *Normal anatomy: the levator veli palatini muscle forms a muscular sling in the posterior aspect of the soft palate.* ***B.*** *Cleft anatomy: the levator veli palatini muscles turn anteriorly, run along the cleft margin, and insert aberrantly into the posterior edge of the hard palate.*

The most clinically useful system to describe cleft palate morphology is the Veau classification:

- *Veau I* cleft is midline and limited to the soft palate alone,
- *Veau II* cleft may extend further anteriorly to involve the midline of the posterior hard palate (the "secondary palate"),
- *Veau III* cleft is a complete unilateral cleft of primary and secondary palates, in which the cleft extends through the lip, the alveolus, the entire length of the nasal floor on the cleft side, and the midline of the soft palate.
- *Veau IV* clefts are bilateral complete clefts of the primary palate that converge at the incisive foramen and continue posteriorly through the entire secondary palate.

Not included in the Veau classification is the submucous cleft palate, which occurs when there is clefting of the soft palate musculature beneath intact mucosa. Submucous cleft palate classically presents as the triad of a bifid uvula, a midline translucency called the pellucid area and a palpable notch of the posterior hard palate.[26]

2.1.3. PRESURGICAL INFANT ORTHOPEDICS

Current literature suggests aesthetic outcomes in patients with complete unilateral or bilateral clefts may be improved by re-stablishing more normal skeletal, cartilaginous, and soft tissue relationships prior to definitive lip repair. Presurgical infant orthopaedics (PSIO) can help to narrow wide clefts and align dental arches in preparation for surgery. Some methods of PSIO, such as nasoalveolar molding (NAM), provide the added benefits of elongating the columella and improving nasal tip asymmetry.[48] The most common barrier to PSIO implementation is its imposition on families, who must be willing and able to keep frequent follow-up appointments for appliance adjustment. An excellent alternative to PSIO is a lip adhesion procedure, in which a complete cleft is surgically converted to an incomplete cleft. This preliminary stage of lip repair restores soft tissue continuity at the nasal sill, which helps to realign the underlying dental arches and reapproximate the soft tissues. In addition, the nasal deformity can be improved, both by repositioning of the cleft side alar base and placement of nasal conformers.[42]

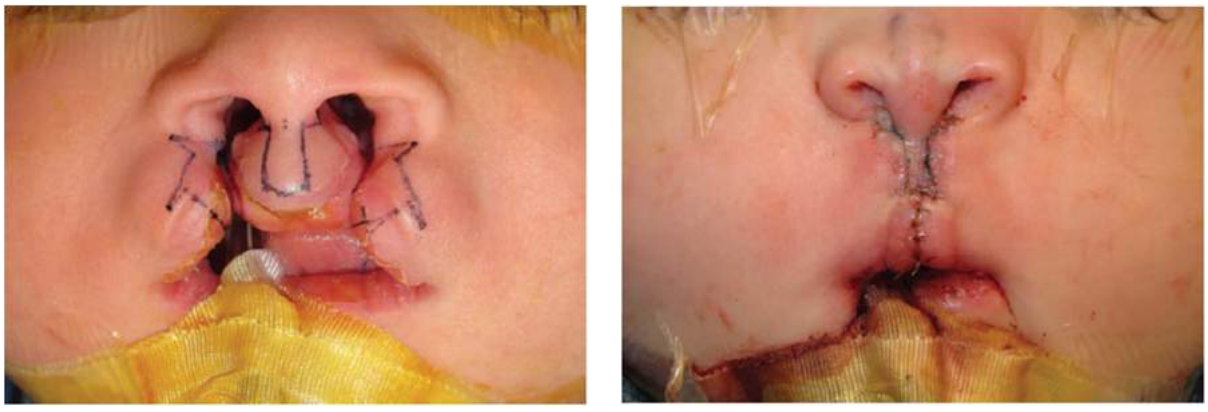
2.1.4. CLEFT LIP REPAIR

Although cleft lip surgery can be traced to antiquity, it was not until the first half of the 20th century that surgeons began to realize the inadequacy of a straight-line repair. In 1955, Ralph Millard pioneered his “rotation-advancement” technique, which was the first to address upper lip length deficiency while preserving intricate philtral anatomy.

The back-cut is designed high on the medial lip element just beneath the columella, enabling a downward *rotation* and leveling of Cupid’s bow, while the lateral lip element is *advanced* into the rotation defect. Although other techniques exist, most lip repairs performed today are minor modifications of Millard’s original rotation-advancement principle.[44]

Bilateral cleft lip presents an even greater set of challenges to the reconstructive surgeon. With no overlying orbicularis oris muscle, an unrestrained premaxilla rotates anteriorly, completely displacing the incisor-bearing portion of the alveolus from the maxillary dental arch. Orbicularis continuity must be restored over an often protuberant premaxilla. The surgeon must carefully recreate the appearance of a symmetrical philtrum and median labial tubercle. Prototypical markings for bilateral cleft lip repair are demonstrated in Fig. 10A,B.[44]

Any surgical approach to bilateral cleft lip repair would be incomplete without addressing the nasal stigmata, which include a short or absent columella, a poorly defined and under-projected nasal tip, and malpositioned lower lateral cartilages. Primary nasoplasty at the time of lip repair has become an increasingly common practice. Nasal skin and soft tissue are dissected free from the underlying cartilaginous framework, allowing for suture manipulation of lower lateral cartilages to improve tipsymmetry, support, and projection.[44]



A B

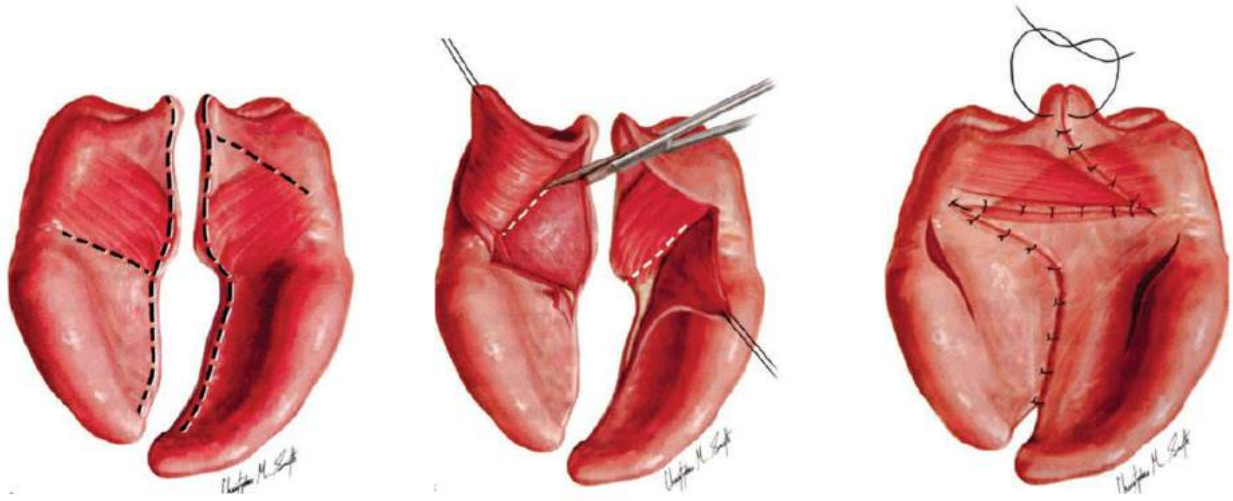
Figure 10. A. Bilateral cleft lip repair diagram. B. Bilateral cleft lip repair.

2.1.5. CLEFT PALAT REPAIR

The primary goal of palatoplasty is to enable normal speech development. A successful palate repair is one that results in a robust, layered reconstruction of the cleft and restoration of functional velar anatomy. The two most common techniques employed for soft palate repair are intravelar veloplasty (IVV) and Furlow double-opposing Z-plasty. Paramount to each technique is the complete release of aberrant levator muscle insertions from the posterior edge of the hard palate. This maneuver untethers the velum anteriorly, enabling maximal levator muscle excursion in the superior and posterior directions postoperatively.[21] Intravelar veloplasty requires meticulous dissection of the levator muscles with retropositioning and reconstruction of the sling mechanism in the posterior aspect of the soft palate.

A Furlow double-opposing Z-plasty involves cleverly designed mirror image Z-plasties on the oral and nasal sides of the soft palate where the central limb of each Z-plasty is the cleft. The posteriorly based flap of mucosa on each surface of the palate incorporates the underlying levator muscle. Transposition of these flaps across the cleft lengthens the palate and, in a manner similar to IVV, corrects levator malposition.

Lateral relaxing incisions can be utilized to relieve tension on the closure, if necessary (Fig. 11A–C).[49] [50] In experienced hands, both techniques have demonstrated excellent speech outcomes and low fistula rates. However, direct comparison between the two methods has been difficult due to ongoing evolution of the IVV technique and wide variability in the extent of dissection between performing surgeons.[46]



A B C

Figure 11. Furlow double opposing Z-plasty. ***A.*** *Oral side markings.* ***B.*** *Nasal side markings. Note that the levator veli palatini muscle remains attached to the posteriorly based flap on each surface.* ***C.*** *Flap transposition and closure. The levator veli palatini muscle bundles, being attached to the posteriorly based flaps, are reoriented transversely and retro-displaced as a result of flap transposition.*

Clefts involving the hard palate (Veau II–IV) often require additional maneuvers for reconstruction. Wide undermining of the nasal floor mucosa in the subperiosteal plane facilitates the nasal-side repair. As palatal mucoperiosteum is thicker and less pliable, the oral-side closure generally requires the use of relaxing incisions along the lingual side of the alveolar ridge. Additional medialization of the palatal soft tissue can be obtained by increasing isolation of the greater palatine neurovascular pedicle, which emerges from its foramen near the posterolateral aspect of the hard palate. Narrow Veau II clefts may be closed on the oral side by medialization of bilateral bi-pedicled mucoperiosteal flaps (von Langenbeck palatoplasty), while wider clefts may require detachment of one or both flaps anteriorly for additional medialization (Bardach two-flap palatoplasty).

Lateral relaxing incisions are left open, and typically heal by secondary intention within two weeks.[49]

Complications of palate repair include oronasal fistula, velopharyngeal dysfunction, obstructive sleep apnoea, and midface growth deficiency. Reported fistula rates vary widely in the literature, but increased incidence has been correlated with less experienced surgeons, wider clefts, and bilateral clefts.[48]

Few oronasal fistulae are amenable to closure with simple local tissue rearrangement. More commonly, a complete re-elevation of palatal mucosa is required in order to obtain a tension-free layered closure. In the case of large or recurrent fistulae, there may be insufficient tissue available locally, and recruitment of regional healthy tissue from the buccal mucosa or tongue may be necessary.[47]

Velopharyngeal dysfunction (VPD) is caused by incomplete closure of the velopharyngeal port, which results in air leaking through the nose during speech. Approximately 20% of patients develop VPD after primary palatoplasty. After insuring complete release and proper orientation of levator muscles, a posterior pharyngeal flap or a sphincter pharyngoplasty may be required to decrease the size of the velopharyngeal gap, allowing nasal air escape during speech.[21] These operations carry a risk of obstructive sleep apnea, so preoperative polysomnography is indicated to rule out significant sleep-disordered breathing at baseline.

2.1.6. TIMELINE OF REPAIR

The longstanding debate regarding optimal timing for lip and palate repair is ongoing. Central to this controversy is the impact of early surgical intervention on speech outcomes

and midface growth. Current evidence suggests earlier palate repair is better for speech but more detrimental to midface growth.[49] Cleft care algorithms represent a compromise. Most experts perform lip repair between 3 and 6 months of age.[50] Palate repair should be completed prior to the onset of speech development, usually around 10 to 12 months of age. The alveolar cleft is often repaired secondarily with a cancellous bone graft from the iliac crest. This operation provides bony support for the permanent teeth that will erupt adjacent to the cleft, and it is usually performed around 7 to 9 years of age.

Orthognathic surgery and secondary rhinoplasty, if necessary, are delayed until skeletal maturity.

2.1.7. THE IMPORTANCE OF TEAM IN CLEFT CARE

As mentioned earlier in the surgery mission description chapter, children born with CL/P require expertise of medical professionals from many different disciplines. In addition to experienced craniofacial surgeons, cleft teams typically consist of otolaryngologists, paediatricians, speech pathologists, feeding specialists, paediatric dentists, orthodontists, geneticists, psychologists, nurses, and social workers. Each member is an integral part of the team and absolutely essential for the delivery of comprehensive cleft care.[49]

2.2. HIRSCHCPRUNG'S DISEASE

2.2.1. PATHOGENESIS

In his classic textbook entitled *Pediatric Surgery,* Dr. Orvar Swenson, who is eponymously associated with one of the classic surgical treatments for Hirschsprung's disease, described this condition as follows: "Congenital megacolon is caused by a malformation in the pelvic parasympathetic system which results in the absence of ganglion cells in Auerbach's plexus of a segment of distal colon. Not only is there an absence of ganglion cells, but the nerve fibers are large and excessive in number, indicating that the anomaly may be more extensive than the absence of ganglion cells." This narrative of Hirschsprung's disease is as accurate today as it was more than 50 years ago and summarizes the essential pathologic features of this disease: absence of ganglion cells in Auerbach's plexus and hypertrophy of associated nerve trunks.

The cause of Hirschsprung's disease remains incompletely understood, although current thinking suggests that the disease results from a defect in the migration of neural crest cells, which are the embryonic precursors of the intestinal ganglion cell.

Under normal conditions, the neural crest cells migrate into the intestine from cephalad to caudad. The process is completed by the 12th week of gestation, but the migration from mid-transverse colon to anus takes 4 weeks. During this latter period, the fetus is most vulnerable to defects in migration of neural crest cells.

This may explain why most cases of aganglionosis involve the rectum and rectosigmoid. The length of the aganglionic segment of bowel is therefore determined by the most distal region that the migrating neural crest cells reach. In rare instances, total colonic aganglionosis may occur.

Recent studies have shed light on the molecular basis for Hirschsprung's disease. Patients with Hirschsprung's disease have an increased frequency of mutations in several genes, including *GDNF*, its receptor *Ret*, or its coreceptor *Gfra-1*.

Initial investigations indicate that *GDNF* promotes the survival, proliferation, and migration of mixed populations of neural crest cells in culture.

Other studies have revealed that *GDNF* is expressed in the gut in advance of migrating neural crest cells and is chemo-attractive for neural crest cells in culture. These findings raise the possibility that mutations in the *GDNF* or *Ret* genes could lead to impaired neural crest migration in utero and the development of Hirschsprung's disease.

2.2.2. CLINICAL PRESENTATION

The incidence of sporadic Hirschsprung's disease is 1 in 5000 live births. There are reports of increased frequency of Hirschsprung's disease in multiple generations of the same family. Occasionally, such families have mutations in the genes described earlier, including the *Ret* gene. Because the aganglionic colon does not permit normal peristalsis to occur, the presentation of Hirschsprung's disease in children is characterized by a functional distal intestinal obstruction. In the new-born period, the most common symptoms are abdominal distention, failure to pass meconium, and bilious emesis.

Any infant who does not pass meconium beyond 48 hours of life must be investigated for the presence of Hirschsprung's disease.

Occasionally, infants present with a dramatic complication of Hirschsprung's disease called *enterocolitis.*

This pattern of presentation is characterized by abdominal distention and tenderness, and it is associated with systemic toxicity manifestations that include fever, failure to thrive, and lethargy. Infants are often dehydrated and demonstrate a leukocytosis or increase in

circulating band forms on hematologic evaluation. On rectal examination, forceful expulsion of foul-smelling liquid feces is typically observed and represents the accumulation of stool under pressure in an obstructed distal colon. Treatment includes rehydration, systemic antibiotics, nasogastric decompression, and rectal irrigations while the diagnosis of Hirschsprung's disease is being confirmed.

In children that do not respond to nonoperative management, a decompressive stoma is required. It is important to ensure that this stoma is placed in ganglion-containing bowel, which must be confirmed by frozen section at the time of stoma creation.

In approximately 20% of cases, the diagnosis of Hirschsprung's disease is made beyond the new-born period.

These children have severe constipation, which has usually been treated with laxatives and enemas. Abdominal distention and failure to thrive may also be present at diagnosis.

2.2.3. DIAGNOSIS

The definitive diagnosis of Hirschsprung's disease is made by rectal biopsy. Samples of mucosa and submucosa are obtained at 1 cm, 2 cm, and 3 cm from the dentate line. This can be performed at the bedside in the neonatal period without anaesthesia, as samples are taken in bowel that does not have somatic innervation and thus is not painful for the child.

In older children, the procedure should be performed using IV sedation or general anaesthesia.

The histopathology of Hirschsprung's disease is the absence of ganglion cells in the myenteric plexuses, increased acetylcholinesterase staining, and the presence of hypertrophied nerve bundles.

It is important to obtain a contrasted enema in children in whom the diagnosis of Hirschsprung's disease is suspected. This test may demonstrate the location of the transition zone between the dilated ganglionic colon and the distal constricted aganglionic rectal segment. Our practice is to obtain this test before instituting rectal irrigations if possible so that the difference in size between the proximal and distal bowel is preserved.

Although the contrasted enema can only suggest, but not reliably establish, the diagnosis of Hirschsprung's disease, it is very useful in excluding other causes of distal intestinal obstruction.

These include small left colon syndrome (as occurs in infants of diabetic mothers), colonic atresia, meconium plug syndrome, or the unused colon observed in infants after the

administration of magnesium or tocolytic agents. The contrasted enema in total colonic aganglionosis may show a markedly shortened colon.

Some surgeons have found the use of rectal manometry helpful, particularly in older children, although it is relatively inaccurate.

2.2.4. TREATMENT

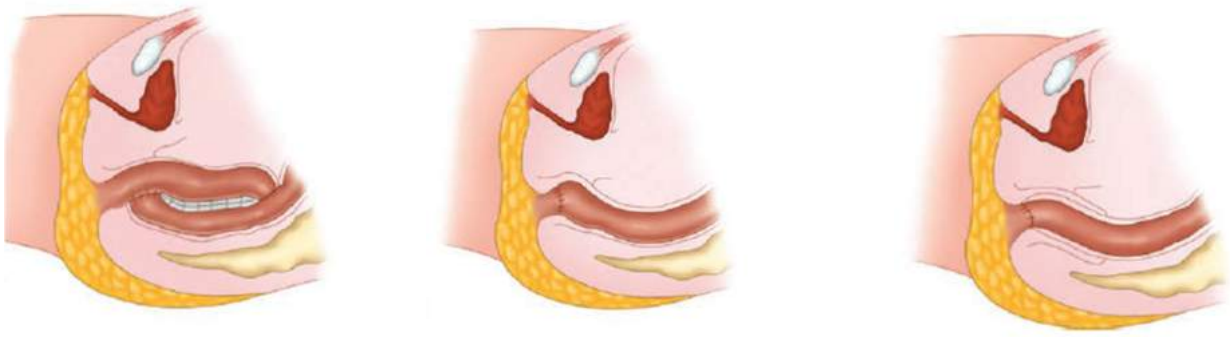
Hirschsprung's disease requires surgery in all cases.

The classic surgical approach consisted of a multiple stage procedure. This included a colostomy in the new-born period, followed by a definitive pull-through operation after the child was over 10 kg.

There are three viable options for the definitive pull through procedure that are currently used.

Although individual surgeons may advocate one procedure over another, studies have demonstrated that the outcome after each type of operation is similar. For each of the operations that is performed, the principles of treatment include confirming the location in the bowel where the transition zone between ganglionic and aganglionic bowel exists, resecting the aganglionic segment of bowel, and performing an anastomosis of ganglionated bowel to either the anus or a cuff of rectal mucosa (Fig. n. 12)[47].

It is now well established that a primary pull-through procedure can be performed safely, even in the new-born period.



A B C

Figure 12. The three operations for surgical correction of Hirschsprung's disease. ***A.*** *The Duhamel procedure leaves the rectum in place and brings ganglionic bowel into the retro-rectal space.* ***B.*** *The Swenson procedure is a resection with end-to-end anastomosis performed by exteriorizing bowel ends through the anus.* ***C.*** *The Soave operation is performed by endorectal dissection and removal of mucosa from the aganglionic distal segment and bringing the ganglionic bowel down to the anus within the seromuscular tunnel.*

This approach follows the same treatment principles as a staged procedure and saves the patient from an additional surgical procedure. Many surgeons perform the intra- abdominal dissection using the laparoscope. This approach is especially useful in the new-born period as this provides excellent visualization of the pelvis.

In children with significant colonic distention, it is important to allow for a period of decompression using a rectal tube if a single-staged pull-through is to be performed.

In older children with very distended, hypertrophied colon, it may be prudent to perform a colostomy to allow the bowel to decompress prior to performing a pull-through procedure. However, it should be emphasized that there is no upper age limit for performing a primary pull-through.

Of the three pull-through procedures performed for Hirschsprung's disease, the first is the original.

In this operation, the aganglionic rectum is dissected in the pelvis and removed down to the anus. The ganglionic colon is then anastomosed to the anus via a perineal approach. In the *Duhamel procedure*, dissection outside the rectum is confined to the retrorectal space, and the ganglionic colon is anastomosed posteriorly just above the anus. The anterior wall of the ganglionic colon and the posterior wall of the aganglionic rectum are anastomosed, using a stapler.

Although both of these procedures are extremely effective, they are limited by the possibility of damage to the parasympathetic nerves that are adjacent to the rectum.

To circumvent this potential problem, *Soave's procedure* involves dissection entirely within the rectum. The rectal mucosa is stripped from the muscular sleeve, and the ganglionic colon is brought through this sleeve and anastomosed to the anus. This operation may be performed completely from trans-anal approach (*De La Torre procedure,* in Fig. n.13). In all cases, it is critical that the level at which ganglionated bowel exists be determined. Most surgeons believe that the anastomosis should be performed at least 5 cm from the point at which ganglion cells are found. This avoids performing a pull-through in the transition zone, which is associated with a high incidence of complications due to inadequate emptying of the pull-through segment.

Up to one-third of patients who undergo a transition zone pull through will require a reoperation.

The main complications of all procedures include postoperative enterocolitis, constipation, and anastomotic stricture.

There is also a reported incidence of recurrent Hirschsprung's disease, which may reflect either residual aganglionic bowel left behind after the pull-through, or the presence of ischemia in the pulled-through segment leading to ganglion cell loss.

Long-term results with the three procedures are comparable and generally excellent in experienced hands.

These three procedures also can be adapted for total colonic aganglionosis in which the ileum is used for the pull-through segment.

Figure 13. De La Torre Procedure. Operated cases from Paediatric Surgery Department of Ferrara.

2.3. ANORECTAL MALFORMATIONS

2.3.1. ANATOMIC DESCRIPTION

Anorectal malformations describe a spectrum of congenital anomalies that include imperforate anus and persistent cloaca.

Anorectal malformations occur in approximately 1 in 5000 live births and affect males and females almost equally.

The embryologic basis includes failure of descent of the uro-rectal septum. The level to which this septum descends determines the type of anomaly that is present, which subsequently influences the surgical approach.

In patients with imperforate anus, the rectum fails to descend through the external sphincter complex. Instead, the rectal pouch ends "blindly" in the pelvis, above or below

the levator ani muscle. In most cases, the blind rectal pouch communicates more distally with the genitourinary system or with the perineum through a fistulous tract.

Traditionally, anatomic description of imperforate anus has been characterized as either "high" or "low" depending on whether the rectum ends above the levator ani muscle complex or partially descends through this muscle (Fig. n. 14).[47]

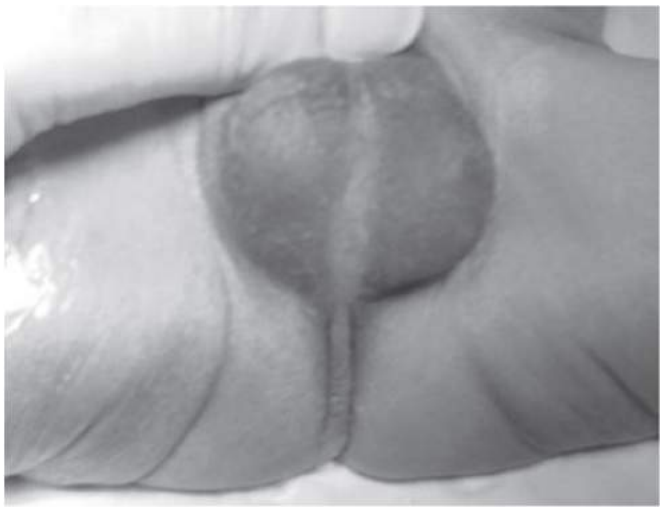


Figure 14. Low imperforate anus in a male. Note the well developed buttocks. The perineal fistula was found at the midline raphe.

Based upon this classification system, in male patients with high imperforate anus the rectum usually ends as a fistula into the membranous urethra.

In females, high imperforate anus often occurs in the context of a persistent cloaca.

In both males and females, low lesions are associated with a fistula to the perineum.

In males, the fistula connects with the median raphe of the scrotum or penis.

In females, the fistula may end within the vestibule of the vagina, which is located immediately outside the hymen or at the perineum.

Because this classification system is somewhat arbitrary, Peña proposed a classification system that specifically and unambiguously describes the location of the fistulous opening.

In men, the fistula may communicate with:

- the perineum (cutaneous perineal fistula);
- the lowest portion of the posterior urethra (rectourethral bulbar fistula);
- the upper portion of the posterior urethra (rectourethral prostatic fistula);
- the bladder neck (rectovesicular fistula).

In females, the urethra may open:

- to the perineum between the female genitalia and the center of the sphincter (cutaneous perineal fistula);
- into the vestibule of the vagina (vestibular fistula).

In both sexes, the rectum may end in a completely blind fashion (imperforate anus without fistula).

In rare cases, patients may have a normal anal canal, yet there may be total atresia or severe stenosis of the rectum.

The most frequent defect in males is imperforate anus with rectourethral fistula, followed by rectoperineal fistula, then rectovesical fistula or recto-bladder neck.

In females, the most frequent defect is the recto-vestibular defect, followed by the cutaneous perineal fistula. The third most common defect in females is the persistent cloaca. This lesion represents a wide spectrum of malformations in which the rectum, vagina, and urinary tract meet and fuse into a single common channel. On physical examination, a single perineal orifice is observed, and it is located at the place where the urethra normally opens. Typically, the external genitalia are hypoplastic.

2.3.2. ASSOCIATED MALFORMATIONS

Approximately 60% of patients have an associated malformation. The most common is a urinary tract defect, which occurs in approximately 50% of patients.

Skeletal defects are also seen, and the sacrum is most commonly involved. Spinal cord anomalies especially tethered cored are common, particularly in children with high lesions. Gastrointestinal anomalies occur, most commonly esophageal atresia.

Cardiac anomalies may be noted, and occasionally patients present with a constellation of defects as part of the VACTERL/VATER syndrome that is a syndrome associated with vertebral anomalies (absent vertebrae or hemivertebrae) and anorectal anomalies (imperforate anus), cardiac defects, tracheoesophageal fistula, renal anomalies / renal agenesis, and radial limb agenesis.

2.3.3 MANAGEMENT OF PATIENTS WITH IMPERFORATE ANUS

Patients with imperforate anus are usually stable, and the diagnosis is readily apparent. Despite the obstruction, the abdomen is initially not distended, and there is rarely any urgency to intervene. The principles of management centre around diagnosing the type of defect that is present (high versus low) and evaluating the presence of associated anomalies. It may take up to 24 hours before the presence of a fistula on the skin is noted, and thus it is important to observe the neonate for some hours before definitive surgery is undertaken.

All patients should therefore have an orogastric tube placed and be monitored for the appearance of meconium in or around the perineum or in the urine. Investigation for associated defects should include an US of the abdomen to assess for the presence of urinary tract anomaly. Other tests should include an echocardiogram and spinal radiographs. An US of the spine should be performed to look for the presence of a tethered cord. To further classify the location of the fistula as either “high” versus “low”, a lateral abdominal radiograph can be obtained with a radiopaque marker on the perineum.

By placing the infant in the inverted position, the distance between the most distal extent of air in the rectum and the perineal surface can be measured. This study is imprecise, however, and may add little to the overall management of these patients.

The surgical management of infants with imperforate anus is determined by the anatomic defect.

In general, when a low lesion is present, only a perineal operation is required without a colostomy.

Infants with a high lesion require a colostomy in the new-born period, followed by a pull-through procedure at approximately 2 months of age.

When a persistent cloaca is present, the urinary tract needs to be carefully evaluated at the time of colostomy formation to ensure that normal emptying can occur and to determine whether the bladder needs to be drained by performing a vesicostomy.

If there is any doubt about the type of lesion, it is safer to perform a colostomy rather than jeopardize the infant’s long-term chances for continence by an injudicious perineal operation.

The type of pull-through procedure favoured by most paediatric surgeons today is the posterior sagittal anorectoplasty (PSARP procedure), as described by Peña and DeVries. This involves placing the patient in the prone jack-knife position, dividing the levator ani

and external sphincter complex in the midline posteriorly, dividing the communication between the gastrointestinal tract and the urinary tract, and bringing down the rectum after sufficient length is achieved. The muscles are then reconstructed and sutured to the rectum. The outcome of 1192 patients who had undergone this procedure has been reviewed by Peña and Hong. 70% of patients were found to have voluntary bowel movements, and nearly 40% were considered totally continent.

As a rule, patients with high lesions demonstrate an increase incidence of incontinence, whereas those with low lesions are more likely to be constipated.

Management of patients with high imperforate anus can be greatly facilitated using a laparoscopic assisted approach, in which the patient is operated on in the supine position, and the rectum is mobilized down to the fistulous connection to the bladder neck.

This fistulous connection is then divided, and the rectum is completely mobilized down to below the peritoneal reflection.

The operation then proceeds at the perineum, and the location of the muscle complex is determined using the nerve stimulator. A Veress needle is then advanced through the skin at the indicated site, with the laparoscope providing guidance to the exact intrapelvic orientation.

Dilators are then placed over the Veress needle, the rectum is then pulled through this peritoneal opening, and an anoplasty is performed.

2.4. VAGINAL ANOMALIES

Surgical diseases of the vagina in children are either congenital or acquired.

Congenital anomalies include a spectrum of diseases that range from simple defects (imperforate hymen) to more complex forms of vaginal atresia, including distal, proximal, and, most severe, complete. These defects are produced by abnormal development of mullerian ducts and/or urogenital sinus.

The diagnosis is made most often by physical examination.

Secretions into the obstructed vagina produce hydrocolpos, which may present as a large, painful abdominal mass. The anatomy may be defined using US. Pelvic magnetic resonance imaging provides the most thorough and accurate assessment of the pelvic structures. Treatment is dependent on the extent of the defect.

For an imperforate hymen, division of the hymen is curative.

More complex forms of vaginal atresia require mobilization of the vaginal remnants and creation of an anastomosis at the perineum.

Laparoscopy can be extremely useful, both in mobilizing the vagina, in draining hydrocolpos, and in evaluating the internal genitalia.

Complete vaginal atresia requires the construction of skin flaps or the creation of a neovagina using a segment of colon.

The most common acquired disorder of the vagina is the straddle injury. This often occurs as young girls fall on blunt objects which cause a direct injury to the perineum. Typical manifestations include vaginal bleeding and inability to void.

Unless the injury is extremely superficial, patients should be examined in the operating room where the lighting is optimal, and sedation can be administered. Examination under anaesthesia is particularly important in girls who are unable to void, suggesting a possible urethral injury.

Vaginal lacerations are repaired using absorbable sutures, and the proximity to the urethra should be carefully assessed. Prior to hospital discharge, it is important that girls are able to void spontaneously.

In all cases of vaginal trauma, it is essential that the patient be assessed for the presence of sexual abuse. In these cases, early contact with the sexual abuse service is necessary so that the appropriate microbiologic and photographic evidence can be obtained.

2.5. DEFORMITIES OF THE ABDOMINAL WALL

2.5.1. EMBRIOLOGY OF THE ABDOMINAL WALL

The abdominal wall is formed by four separate embryologic folds: cephalic, caudal, right, and left lateral folds. Each of these is composed of somatic and splanchnic layers and develops toward the anterior centre portion of the coelomic cavity, joining to form a large umbilical ring that surrounds the two umbilical arteries, the vein, and the yolk sac or omphalomesenteric duct. These structures are covered by an outer layer of amnion, and the entire unit composes the umbilical cord.

Between the 5th and tenth weeks of fetal development, the intestinal tract undergoes rapid growth outside the abdominal cavity within the proximal portion of the umbilical cord. As development is completed, the intestine gradually returns to the abdominal cavity. Contraction of the umbilical ring completes the process of abdominal wall formation.

Failure of the cephalic fold to close results in sternal defects such as congenital absence of the sternum. Failure of the caudal fold to close results in exstrophy of the bladder and, in more extreme cases, exstrophy of the cloaca.

Interruption of central migration of the lateral folds results in omphalocele.

Gastroschisis, originally thought to be a variant of omphalocele, possibly results from a fetal accident in the form of intrauterine rupture of a hernia of the umbilical cord, although other hypotheses have been advanced.

The most common deformities of the abdominal wall are umbilical and inguinal hernias.

Umbilical hernia. (Fig n. 15) Failure of the umbilical ring to close results in a central defect in the linea alba. The resulting umbilical hernia is covered by normal umbilical skin and subcutaneous tissue, but the fascial defect allows protrusion of abdominal contents.

Inguinal hernia. It results from a failure of closure of the processus vaginalis; a finger-like projection of the peritoneum that accompanies the testicle as it descends into the scrotum. Closure of the processus vaginalis normally occurs a few months prior to birth. This explains the high incidence of inguinal hernias in premature infants. When the processes vaginalis remains completely patent, a communication persists between the peritoneal cavity and the groin, resulting in a hernia. Partial closure can result in entrapped fluid, which results in the presence of a *hydrocele*.

Figure 15. Umbilical hernia in a 1-year-old female.

2.5.2. OMPHALOCELE

Omphalocele refers to a congenital defect of the abdominal wall in which the bowel and solid viscera are covered by peritoneum and amniotic membrane (Fig. 16)

The umbilical cord inserts into the sac. Omphalocele can vary from a small defect with intestinal contents to giant omphalocele in which the abdominal wall defect measures 4 cm or more in diameter and contains liver.

The overall incidence is approximately 1 in 5000 live births, with 1 in 10,000 that are giant omphaloceles.

Omphalocele occurs in association with special syndromes such as exstrophy of the cloaca (vesicointestinal fissure), the Beckwith-Wiedemann constellation of anomalies (macroglossia, macrosomia, hypoglycemia, and visceromegaly and omphalocele) and Cantrell's Pentalogy (lower thoracic wall malformations [cleft sternum], ectopia cordis, epigastric omphalocele, anterior midline diaphragmatic hernia and cardiac anomalies).

Figure 16. Giant omphalocele in a new-born male.

There is a 60% to 70% incidence of associated anomalies, especially cardiac (20–40% of cases) and chromosomal abnormalities. Chromosomal anomalies are more common in children with smaller defects. Omphalocele is associated with prematurity (10–50% of cases) and intrauterine growth restriction (20% of cases).

Immediate treatment of an infant with omphalocele consists of attending to the vital signs and maintaining the body temperature. A blood glucose should be evaluated because of the association with Beckwith-Wiedemann.

The omphalocele should be covered to reduce fluid loss, but moist dressings may result in heat loss and are not indicated. No pressure should be placed on the omphalocele sac in an effort to reduce its contents because this maneuver may increase the risk of rupture of the sac or may interfere with abdominal venous return.

Prophylactic broad-spectrum antibiotics should be administered in case of rupture.

The subsequent treatment and outcome are determined by the size of the omphalocele. In general terms, small to medium sized defects have a significantly better prognosis than extremely large defects in which the liver is present. In these cases, the management of the abdominal wall defect is not the only significant challenge, but these patients often have concomitant pulmonary insufficiency that can lead to significant morbidity and mortality. Some infants may have associated congenital anomalies that complicate surgical repair, and because cardiac anomalies are common, an echocardiogram should be obtained prior to any procedure.

Where possible, and if the pulmonary status will permit it, a primary repair of the omphalocele should be undertaken. This involves resection of the omphalocele membrane and closure of the fascia.

A layer of prosthetic material may be required to achieve closure. In infants with a giant omphalocele, the defect cannot be closed primarily because there is not adequate intraperitoneal domain to reduce the viscera (Fig. 16).[47]

If primary repair is not possible, such as with a very large defect, a staged abdominal wall closure is necessary; this can be done using a Dacron re-forced Silastic silo as a temporary extra-abdominal locale for the bowel. The silo – sutured to the skin at the edge of the abdominal wall defect – should be constructed with his walls perpendicular to the abdominal wall and parallel to each other. The content of the sac is supported by umbilical tape suspended from the top of the incubator and attached to the apex of the silo. The viscera can be reduced gradually over 3 to 10 days, than the infant is returned to the operating room for removal of the prosthesis and a formal closure of the abdominal wall.[51]

On rare occasions, when the defect is larger than 10 cm and takas up much of the anterior abdominal wall, a nonoperative approach can be used. The omphalocele sac can be treated with topical treatments, which serve to harden the sac to allow for more protective coverage where muscle and skin cannot be used given the large defect. Various authors

describe success with iodine-containing solutions, silver sulfadiazine, or saline, and some surgeons rotate these solutions because of the impact of iodine on the thyroid and the difficulty of cleaning off all of the silver sulfadiazine and its association with leukopenia.

It typically takes 2 to 3 months before re-epithelialization occurs. In the past, mercury compounds were used, but they have been discontinued because of associated systemic toxicity.

After epithelialization has occurred, attempts should be made to achieve closure of the anterior abdominal wall but may be delayed by associated pulmonary insufficiency. Such procedures typically require complex measures to achieve skin closure, including the use of biosynthetic materials or component separation. In cases of giant omphalocele, prolonged hospitalization is typical. If the base is very narrow (which can occur even for babies with very large omphaloceles) it may be wise to open the base in order to allow the abdominal contents and the liver to re-enter the abdominal cavity, and thereby achieve abdominal domain. This approach will, by necessity, require sewing in some synthetic material in order to achieve fascial closure, and prolonged hospitalization will be required to allow for skin coverage to occur.

These patients require high amounts of caloric support, given the major demands for healing.

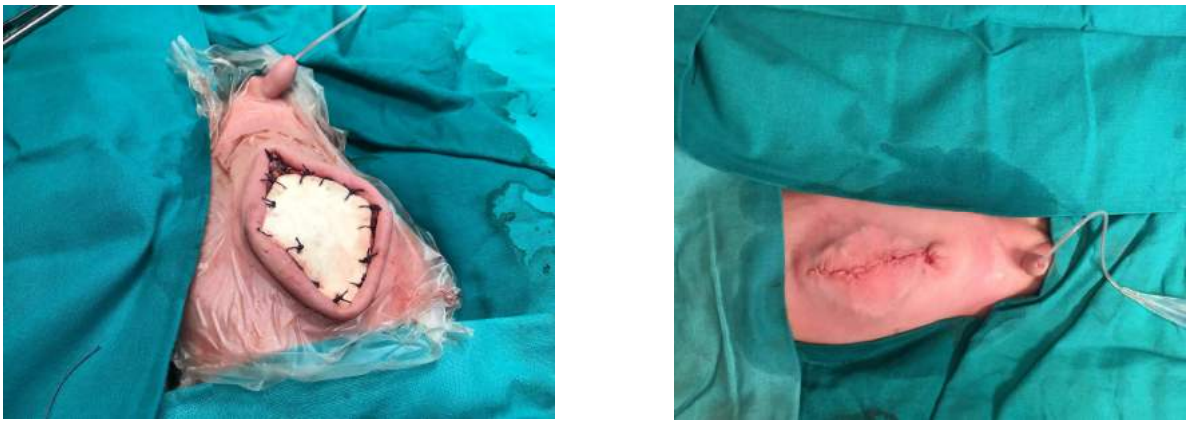


Figure 17. Operated omphalocele with Goretex Patch.

2.6. UNDENSCENDED TESTIS

The term undescended testicle (or cryptorchidism or UDT) refers to the interruption of the normal descent of the testis into the scrotum. The testicle may reside in the retroperitoneum, in the internal inguinal ring, in the inguinal canal, or even at the external ring.

The testicle begins as a thickening on the urogenital ridge in the 5^{th} to 6^{th} week of embryologic life. In the 7^{th} and 8^{th} months, the testicle descends along the inguinal canal into the upper scrotum, and with its progress the processus vaginalis is formed and pulled along with the migrating testicle. At birth, approximately 95% of infants have the testicle normally positioned in the scrotum.

Cryptorchidism or undescended testes (UDT) is a common condition occurring in 3% of full term and 30% of premature babies. Many of these testes will descend spontaneously due to the normal gonadotropin release that occurs in the first few months of life, so the true incidence is roughly 1% of boys.[52]

Cryptorchidism is usually an isolated finding, but it may occur as a part of a systemic condition such as Prader-Willi, Eagle-Barrett, or other such complex multisystem syndrome.

A distinction should be made between an undescended testicle and an ectopic testicle. An ectopic testis, by definition, is one that has passed through the external ring in the normal pathway and then has come to rest in an abnormal location overlying either the rectus abdominis or external oblique muscle, or the soft tissue of the medial thigh, or behind the scrotum in the perineum.

A congenitally absent testicle results from failure of normal development or an intrauterine accident leading to loss of blood supply to the developing testicle.

Untreated cryptorchidism will lead to testis damage, and there is evidence that permanent changes may occur by 3 years of age.

Ideally, surgical treatment should occur prior to this age.

A child with unilateral cryptorchidism should have surgical correction of the problem. The operation is typically performed through a combined groin and scrotal incision.

The cord vessels are fully mobilized, and the testicle is placed in a dartos pouch within the scrotum. An inguinal hernia often accompanies a cryptorchid testis. This should be repaired at the time of orchidopexy.

Patients with a nonpalpable testicle present a challenge in management. The current approach involves laparoscopy to identify the location of the testicle. If the spermatic cord is found to traverse the internal ring or the testis is found at the ring and can be delivered into the scrotum, a groin incision is made and an orchidopexy is performed.

If an abdominal testis is identified that is too far to reach the scrotum, a two-staged Fowler-Stephens approach is used. In the first stage, the testicular vessels are clipped laparoscopically, which promotes the development of new blood vessels along the vas deferens. Several months later, the second stage is performed during which the testis is mobilized laparoscopically along with a swath of peritoneum with collateralized blood supply along the vessel.

Preservation of the gubernacular attachments with its collaterals to the testicle may confer improved testicular survival following orchidopexy in over 90%. It is, nonetheless, preferable to preserve the testicular vessels whenever possible and complete mobilization of the testicle with its vessels intact.

2.7. HYPOSPADIAS

Hypospadias, a condition which may be considered a form of incomplete maturation of the genitalia, is a common abnormality that occurs in 1 out of 250 to 300 new-born boys.

The most obvious aspect of hypospadias is a urethral opening that is not at the tip of the glans, and 70% to 80% of affected babies will have a meatus on the mid to distal shaft or proximal glans.[47] (Fig. n. 18)[53]

A lesser number will have more proximal openings, whether penoscrotal, scrotal, or perineal. In addition to an abnormally located meatus, boys usually have deficient ventral foreskin. Associated penile curvature, more common in the severe varieties, is referred to as *chordee*.

No diagnostic studies are needed for the majority of boys with hypospadias as there is typically no increased risk of renal or bladder anomalies.

Children with associated cryptorchidism, especially with proximal hypospadias and a nonpalpable testis, have an increased risk of a having a coexisting disorder of sexual differentiation (DSD) and need to undergo a thorough evaluation including hormonal studies, karyotype, and pelvic ultrasonography.[54]

Distal hypospadias can usually be repaired in one stage with success rates of greater than 95%.

Most would advocate a staged approach to proximal hypospadias with correction of penile curvature at the first stage and formal urethral reconstruction at the second.[55]

Adults with corrected hypospadias usually have normal sexual function and fertility.

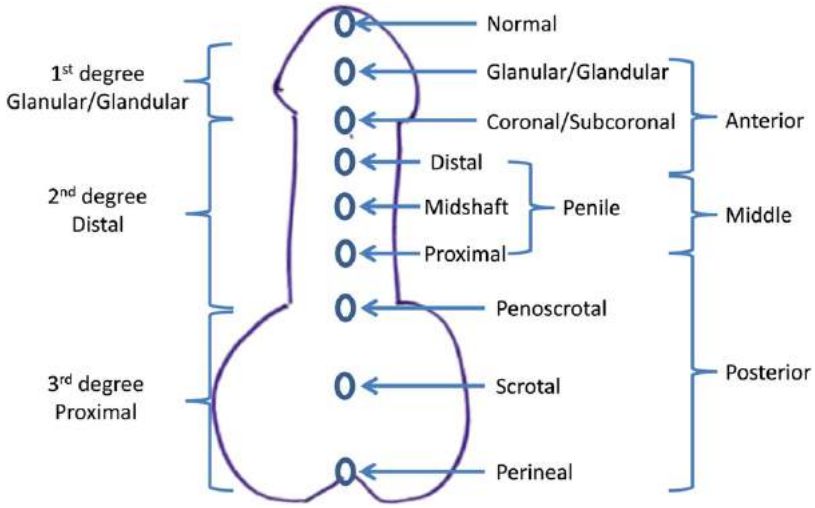


Figure 18. Diagram of commonly used classifications of hypospadias, based on location of urethral meatus. These categories were described by Boisen, Duckett, Hadidi , and Smith.

2.8. CONGENITAL DIFFERENCES OF HANDS

Congenital differences oh hands in a new-born can be particularly disabling as the child learns to interact with the environment by using the hands, especially in rural context.

The degree of anomaly can range from minor, such as a digital disproportion, to severe, such as total absence of a forearm bone.

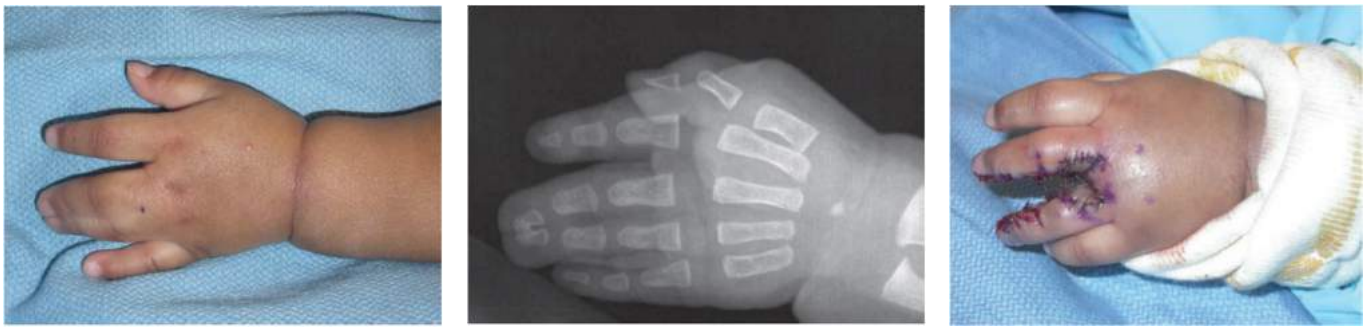
Congenital hand differences have an incidence of 1:1500 births. The two most common differences encountered are syndactyly and polydactyly.[56]

There are numerous classification systems for hand differences.

The Swanson classification, adopted by the American Society for Surgery of the Hand, delineates seven groups organized based on anatomic parts affected by types of embryonic failures.[57]

- *Failure of Formation.* The failure of the formation of parts is a group of congenital differences that forms as a result of a transverse or longitudinal arrest of development. Conditions in this group include radial club hand, a deformity that involves some or all of the tissues on the radial side of the forearm and hand, and ulnar club hand, which involves underdevelopment or absence of the ulnar-sided bones.

- *Failure of Differentiation.* The failure of the differentiation of parts comprises conditions where the tissues of the hand fail to separate during embryogenesis. Syndactyly, in which two or more fingers are fused together, is the most common congenital hand deformity and occurs in 7 out of every 10,000 live births. There is a familial tendency to develop this deformity. This deformity often involves both hands, and males are more often affected than females. Syndactyly is classified as either simple (soft tissue only) or complex (bone and/or cartilage also involved), and complete (full length of the digits) or incomplete (less than the full length). Surgical release of syndactyly requires the use of local flaps to create a floor for the interdigital web space and to partially surface the adjacent sides of the separated digits (Fig. 19).[47] Residual defects along the sides of the separated fingers are covered with full-thickness skin grafts. Surgery usually is performed at 6 to 12 months of age.
- *Duplication* (also known as polydactyly). Radial polydactyly is usually manifests as thumb duplication. Wassel described a classification system for thumb duplications based on the level of bifurcation.[58] When two thumbs are present in the same hand, they are rarely both normal in size, alignment, and mobility. In the most common form of thumb duplication, a single broad metacarpal supports two proximal phalanges, each of which supports a distal phalanx. Optimal reconstruction requires merging of elements of both component digits. Usually the ulnar thumb is maintained. If the duplication occurs at the MP joint, the radial collateral ligament is preserved with the metacarpal and attached to the proximal phalanx of the retained ulnar thumb. Surgery is usually performed at 6 to 12 months of age. Ulnar-sided polydactyly may often be treated by simple excision of the extra digit.
- *Overgrowth* (also known as macrodactyly) which causes an abnormally large digit. In this rare condition, all parts of a digit are affected; however, in most cases, only one digit is involved, and it is usually the index finger. This condition is more commonly seen in males. Surgical treatment of this condition is complex, and the outcomes may be less than desirable. Sometimes, amputation of the enlarged digit provides the best functional result.



A B C

Figure 19. Syndactyly. ***A.*** *Hand of a 1-year-old patient with complex syndactyly between the long and ring fingers. Complex syndactyly refers to fingers joined by bone or cartilaginous union, usually in a side-to-side fashion at the distal phalanges.* ***B.*** *Anteroposterior radiograph.* ***C.*** *The syndactyly is divided with interdigitating full-thickness flaps, a dorsal trapezoidal-shaped flap to resurface the floor of the web space, and full-thickness skin grafts. Note the skin grafts on the ulnar and radial sides of the new web space.*

2.9. BURNS

We will give ample space to this topic because of the very high presence of this type of injuries in LMICs.

Surgical care of the burned patient has evolved into a specialized field incorporating the interdisciplinary skills of burn surgeons, nurses, burn therapists, and other healthcare specialists.

Naturally, general surgeons and paediatric surgeons especially may be at the forefront in these events, so it is crucial that they are comfortable with the care of burned patients and well equipped to provide the standard of care.

2.9.1. BACKGROUND

Burn injury historically carried a poor prognosis. With advances in fluid resuscitation and the advent of early excision of the burn wound,[59] survival has become an expectation even for patients with severe burns.[60]

Continued improvements in critical care and progress in skin bioengineering herald a future in which functional and psychologic outcomes are equally important as survival alone.

Specific criteria should guide transfer of patients with more complex injuries or other medical needs to a burn center. The *American Burn Association* (ABA) has published

standards of care[61] and created a verification process to ensure that burn centers meet those standards.[62] However, in LMICs this kind of centre often do not exist for obvious economic and organization reasons.

2.9.2. INITIAL EVALUATION

Initial evaluation of the burned patient should follow the same initial priorities of all trauma patients and involves four crucial assessments: airway management, evaluation of other injuries, estimation of burn size, and diagnosis of CO and cyanide poisoning.

With direct thermal injury to the upper airway or smoke inhalation, rapid and severe airway oedema is potentially lethal. Anticipating the need for intubation and establishing an early airway control are critical. Signs of impending respiratory compromise include a hoarse voice, wheezing, or stridor; subjective dyspnoea is a particularly concerning symptom and should trigger prompt elective endotracheal intubation.

Perioral burns and singed nasal hairs alone do not indicate an upper airway injury but are signs that the oral cavity and pharynx should be further evaluated for mucosal injury.

Burned patients are trauma patients and evaluated with a primary survey in accordance with Advanced Trauma Life Support guidelines. Concurrently with the primary survey, large-bore peripheral intravenous (IV) catheters should be placed and fluid resuscitation should be initiated; for a burn larger than 40% total body surface area (TBSA), two large-bore IVs are ideal. IV placement through burned skin is safe and effective but requires attention to securing the catheters. Central venous access and intraosseous (IO) access should be considered when peripheral access cannot be easily obtained.

Rarely, IV resuscitation is indicated in patients with burns smaller than 15% who can usually hydrate orally. But Paediatric patients with burns larger than 15% may require IO access in emergent situations if venous access cannot be attained and should be titrated to mean arterial pressure (MAP) >60 mmHg and appropriate urine output.

Early and comprehensive secondary survey must be performed on all burn patients, but especially those with a history of associated mechanical trauma such as a motor vehicle collision and patients from structural fires.

Urgent radiology studies, such as a chest X-ray, should be performed in the emergency department. Hypothermia is a common prehospital complication that contributes to resuscitation failure. Patients should be wrapped with clean blankets in transport.

Cooling should be avoided in patients with moderate or large (>20% TBSA) burns. Patients with acute burn injuries should never receive prophylactic antibiotics. This intervention has been clearly demonstrated to promote development of fungal infections and resistant organisms and was abandoned in the mid-1980s.[63]

A tetanus booster should be administered in the emergency department depending on patient immunization status.

The importance of pain management for these patients has been widely recognized over the past 25 years. While pain management is a priority for burn patients, it is important to acknowledge the opioid crisis and the recent push toward decreasing opiate use in general. In order to limit opiate-related morbidity, it is recommended responsible opiate use in conjunction with multimodal pain control and development of a weaning plan starting at opioid commencement.

Anxiety is another component of the psychological response of burn patients, seen with both wound care and general postinjury hospital course.

Benzodiazepines are a staple in the treatment of acute anxiety.

Most burn resuscitation formulas estimate fluid requirements based on burn size measured as a percentage of TBSA (%TBSA). The “rule of nines” is a crude but quick and effective method of estimating burn size.

In children under 3 years old, the head accounts for a larger relative surface area and should be taken into account when estimating burn size. For smaller or odd-shaped burns, the “rule of the palm” where the palmar surface of the hand, including the digits, is 1% TBSA is useful. Diagrams such as the Lund and Browder chart give a more accurate accounting of the true burn size in children and adults.

Superficial or first-degree burns should not be included when calculating burn size, and thorough cleaning of soot and debris is mandatory to avoid confusing soiled skin with burns.[47]

2.9.3. BURN CLASSIFICATION

Burns are commonly classified as:

- thermal,
    - flame, the most common cause for hospital admission of burns, and have the highest mortality. This is primarily related to their association with structural fires and the accompanying inhalation injury and/or CO poisoning

    - contact,
    - scald burns
- electrical burns, make up 3% of U.S. hospital admissions but have special concerns,[64] including cardiac arrhythmia and compartment syndrome with concurrent rhabdomyolysis
- chemical burns, also comprise 3% of admitted burn patients[64] and result in potentially severe burns. Typically, acid chemical burns result in coagulation necrosis and alkali chemical burns cause liquefactive necrosis (with an exception of hydrofluoric acid, which also causes liquefactive necrosis).[65]

The most important components of initial therapy are careful removal of the toxic substance from the patient and irrigation of the affected area with water for a minimum of 30 minutes.

The offending agents in chemical burns can be systemically absorbed and may cause specific metabolic derangements.

2.9.4. BURN DEPTH

Based on the original burn depth classification by Dupuytren in 1832,[66] burn wounds are commonly classified as superficial (first-degree), partial-thickness (second-degree), full-thickness (third-degree), and fourth-degree burns, which affect underlying soft tissue. Fifth-degree burns (through muscle to bone) and sixth degree burns (charring bone) were also described although are less common. Partial-thickness burns are classified as either superficial or deep partial-thickness burns by depth of involved dermis. Clinically, first-degree burns are painful but do not blister, second-degree burns have dermal involvement and are extremely painful with weeping and blisters, and third-degree burns are leathery, painless, and non-blanching.

Jackson described three zones of tissue injury following burn injury.[67] The zone of coagulation is the most severely burned portion and is typically in the centre of the wound. As the name implies, the affected tissue is coagulated and sometimes frankly necrotic, much like a full thickness burn, and will need excision and grafting.

Peripheral to that is a zone of stasis, with variable degrees of vasoconstriction and resultant ischemia, much like a second degree burn. Appropriate resuscitation and wound care may prevent conversion to a deeper wound, but infection or suboptimal perfusion may result in

an increase in burn depth. This is clinically relevant because many superficial partial-thickness burns will heal with nonoperative management, and the majority of deep partial-thickness burns benefit from excision and skin grafting. The outermost area of a burn is called the zone of hyperaemia, which will heal with minimal or no scarring and is most like a superficial partial thickness burn or first-degree burn.[47]

Figure 20. Full thickness burn.

Figure 21. Extensive third-degree burn. Case from the long-term surgical mission in Kenya.

2.9.5. PROGNOSIS

Analysis of multiple risk factors for predicting burn mortality has validated age and burn size with inhalation injury as the strongest predictors of mortality and they are the most robust indicators for burnmortality.[68]

In nonelderly patients, comorbidities such as preinjury human immunodeficiency virus (HIV), metastatic cancer, and kidney or liver disease may influence mortality and length of stay.[69]

Other factors associated with mortality included female gender, and treatment in urban private hospitals (as opposed to urban academic hospitals).[70]

Mortality is not the only outcome of interest in the burn population. Burn injury can significantly impact the subsequent quality of life for survivors, including but not limited to appearance, mobility, functional status, and ability to work. One study found that burn injury reduces short term quality of life by 30% and long-term quality of life by approximately 11%.[71] One factor impacting quality of life is itching (a late and bothersome consequence of burn injury that affects both adult and paediatric population).[73] Other factors include hypertrophic scarring, contracture, and heterotopic ossification. Finally, return to work or school has been a useful tool to evaluate recovery and prognosis, for example, a recent meta-analysis found that approximately 28% of burn survivors never return to work.[73] The return to school for paediatric patients is actually very prompt, averaging about 10 days after discharge.

It is important to recognize these potential quality-of-life issues in burn patients and take necessary steps to diminish the impact that burn injury has on quality of life both in the hospital and following discharge.

2.9.6. RESUSCITATION

A myriad of formulas exists for calculating fluid needs during burn resuscitation, suggesting that no one formula benefits all patients. The most commonly used formula, the Parkland or Baxter formula, consists of 3 to 4 mL/kg per % burn of Lactated Ringer's, of which half is given during the first 8 hours after burn and the remaining half is given over the subsequent 16 hours.[74]

The concept behind continuous fluid requirements is simple. The burn (and/or inhalation injury) drives an inflammatory response that leads to capillary leak; as plasma leaks into the extravascular space, crystalloid administration maintains the intravascular volume.

Continuation of fluid volumes should depend on the time since injury, urine output, and mean arterial pressure (MAP).

Children under 20 kg have the additional requirement: they do not have sufficient glycogen stores to maintain an adequate glucose level in response to the inflammatory response. Specific paediatric formulas have been described, but the simplest approach is to deliver a weight-based maintenance IV fluid with glucose supplementation in addition to the calculated resuscitation with lactated Ringer's.

A number of parameters are widely used to gauge burn resuscitation, but the most common remain the simple outcomes of blood pressure and urine output. As in any critically ill patient, a target MAP of 60 mmHg ensures optimal end-organ perfusion. Goals for urine output should be 1 to 1.5 mL/kg per in paediatric patients. Because blood pressure and urine output may not correlate perfectly with true tissue perfusion, the search continues for other adjunctive parameters that may more accurately reflect adequate resuscitation as serum lactate and base deficit.[47]

The patients receiving higher fluid volumes were at increased risk of complications and death.[75] Common complications include abdominal compartment syndrome, extremity compartment syndrome, intraocular compartment syndrome, and pleural effusions. Monitoring bladder pressures can provide valuable information about development of intra-abdominal hypertension.

The use of colloid as part of the burn resuscitation may decrease overall fluid volumes and potentially may decrease associated complications such as intra-abdominal hypertension.

Other adjuncts are being increasingly used during initial burn resuscitation. High-dose ascorbic acid (vitamin C) may decrease fluid volume requirements and ameliorate respiratory embarrassment during resuscitation, although no mortality benefit has been noted thus far in two trials.[76]

Plasmapheresis has also been associated with decreased fluid requirements and it is postulated that plasmapheresis may filter out inflammatory mediators, thus decreasing ongoing vasodilation and capillary leak.

Determining patient cardiac function and volume status with ultrasonography may guide fluid resuscitation.

The role of blood transfusion in critically injured patients has undergone a re-evaluation in recent years. A large multicentric study of blood transfusions in burn patients found that increased numbers of transfusions were associated with increased infections and higher mortality in burn patients, even when correcting for burn severity.[47]

2.9.7. INHALATION INJURY MANAGEMENT

Inhalation injuries are commonly seen in tandem with burn injuries and are known to increase mortality in burned patients.

Smoke inhalation is present in as many as 35% of hospitalized burn patients and may triple the hospital stay compared to isolated burn injuries.[77] Mortality for inhalation injury has been reported to be as high as 25%, with this increasing to 50% in patients with ≥20% TBSA burns.[78]

The combination of burns, inhalation injury, and pneumonia increases mortality by up to 60% over burns alone. Subsequent development of the adult respiratory distress syndrome (ARDS) is common in these patients and may be caused in part by recruitment of alveolar leukocytes with an enhanced endotoxin activated cytokine response.[79]

Smoke inhalation causes injury in two ways: by direct heat injury to the upper airways (causes airway swelling that typically leads to maximal oedema in the first 24 to 48 hours after injury) and inhalation of combustion products into the lower airways (cause lower airway injury).

The most common physiologic derangement seen with inhalation injury is increased fluid requirement during resuscitation.

Treatment of inhalation injury consists primarily of supportive care. Aggressive pulmonary toilet and routine use of nebulized bronchodilators such as Albuterol are recommended. Nebulized N-acetylcysteine is an antioxidant free radical scavenger designed to decrease the toxicity of high oxygen concentrations.

An important contributor to early mortality in burn patients and often seen in patients with inhalation injury is carbon monoxide (CO) poisoning. This clear, odorless gas has an affinity for haemoglobin that is approximately 200 to 250 times more than that of oxygen.

New ventilator strategies have contributed to the improved mortality with ARDS. Although ARDS still contributes to mortality in burn patients, treatments have improved so that mortality is primarily from multisystem organ failure rather than isolated respiratory causes.[81]

2.9.8. TREATMENT OF THE BURN WOUND

Multitudes of topical therapies exist for the treatment of burn wounds, many of which contain antimicrobial properties.

- *Silver sulfadiazine* is one of the most widely used in clinical practice. It has a wide range of antimicrobial activity, primarily as prophylaxis against burn wound infections rather than treatment of existing infections. It has the added benefits of being inexpensive, being easily applied, and having soothing qualities. It is not significantly absorbed systemically and thus has minimal metabolic derangements. Silver sulfadiazine has a reputation for causing neutropenia, but this association is more likely due to neutrophil margination from the inflammatory response following burn injury. Silver sulfadiazine destroys skin grafts and is contraindicated on burns or donor sites in proximity to newly grafted areas. Also, silver sulfadiazine may retard epithelial migration in healing partial thickness wounds.[47]
- *Mafenide acetate*, either in cream or solution form, is an effective topical antimicrobial. It is effective even in the presence of eschar and can be used in both treating and preventing wound infections; the solution formulation is an excellent antimicrobial for fresh skin grafts. Use of mafenide acetate may be limited by pain with application to partial-thickness burns.[47]
- *Silver nitrate* has broad-spectrum antimicrobial activity as a topical solution. The solution used must be diluted (0.5%), and prolonged topical application leads to electrolyte extravasation with resulting hyponatremia.

Meshed skin grafts in which the interstices are nearly closed are another indication for use of these agents, preferably with greasy gauze to help retain the ointment in the affected area. All three have been reported to cause nephrotoxicity and should be used sparingly in large burns.

- *Silver-impregnated dressings* are increasingly being used for donor sites, skin grafts, and partial-thickness burns because of their potential to avoid daily dressing changes. These may be more comfortable for the patient, but they limit serial wound examinations.
- *Biologic membranes* provide a prolonged barrier under which wounds may heal. Because of the occlusive nature of these dressings, these are typically used only on fresh, superficial, partial-thickness burns that are clearly not contaminated.[47]

2.9.9. NUTRITION

Nutritional support may be more important in patients with large burns than in any other patient population. Adequate nutrition plays a role in acute issues such as immune responsiveness.

Early enteral feeding for patients with burns >20% TBSA is safe and may reduce loss of lean body mass, slow the hypermetabolic response, and result in more efficient protein metabolism.[81]

Early enteral feeds have also been associated with decreased rates of wound infection. If the enteral feeds are started within the first few hours after admission, gastric ileus may be avoided.

Adjuncts such as metoclopramide promote gastrointestinal motility; if other measures for gastric feeding are unsuccessful, advancing the tube into the small bowel with naso-jejunal feeding can be attempted.[47]

Immune-modulating supplements such as glutamine may decrease infectious complications in burn patients.

Micronutrient supplementation with antioxidant vitamins (vitamin E and ascorbic acid) and trace minerals (selenium, zinc, and copper) optimizes wound healing, enhances immune function, and fights oxidative stress.[47]

A commonly used formula in non-burned patients is the Harris-Benedict equation (which calculates caloric needs using factors such as gender, age, height, and weight) may be inaccurate in burns of <40% TBSA, and in these patients, the Curreri formula (which estimates caloric needs to be 25 kcal/kg per day plus 40 kcal/%TBSA per day) may be more appropriate.

β-Blocker use in paediatric patients decreases heart rate and resting energy expenditure and abrogates protein catabolism, even in long-term use.

The anabolic steroid oxandrolone has been extensively studied in burn patients as well and has demonstrated improvements in lean body mass and bone density in severely burned children and it has also been associated with overall decreased mortality in patients with large burns.

Hyperglycaemia has been associated with increased mortality after burn injury, and intensive insulin therapy in critically ill patients has shown benefit, presumably from avoidance of hyperglycaemia. However, in burn patients, the insulin itself may have a metabolic benefit, with improvements in lean body mass and amelioration of the

inflammatory response to burn injury. Oral hypoglycaemic agents such as metformin also help to avoid hyperglycaemia and may contribute to prevention of muscle catabolism.[47]

2.9.10. COMPLICATIONS IN BURN CARE

There are several complications commonly associated with treatment of burn patients and maintaining vigilance for typical complications and using appropriate techniques for prevention may limit the frequency and severity of complications.

Ventilator-associated pneumonia, as in all critically ill patients, is a significant problem in burned patients.

Practical considerations such as protection of facial skin grafts may influence the decision for tracheostomy placement. One major consideration in deciding whether to perform a tracheostomy has been the presence of eschar at the insertion site, which complicates tracheostomy site care and increases the risk of airway infection.

Massive resuscitation of burned patients may lead to an abdominal compartment syndrome characterized by increased airway pressures with hypoventilation and decreased urine output and hemodynamic compromise.

Decompressive laparotomy is the standard of care for refractory abdominal compartment syndrome but carries an especially poor prognosis in burn patients.[82]

Patients undergoing massive resuscitation also develop elevated intraocular pressures and may require lateral canthotomy.[47]

Deep vein thrombosis (DVT) and prophylaxis in the burn population has received increasing attention in the literature recently. Up to 25% of burn patients develop DVT, and fatal pulmonary emboli have been reported in burn patients.[47]

It appears that heparin prophylaxis is safe in burn patients and may help prevent thrombotic complications.

Burn patients often require central venous access for fluid resuscitation and hemodynamic monitoring. Because of the anatomic relation of their burns to commonly used access sites, burn patients may be at higher risk for catheter-related bloodstream infections.[47]

2.9.11. SURGERY TREATMENT

Full-thickness burns with a rigid eschar can form a tourniquet effect as the oedema progresses, leading to compromised venous outflow and eventually arterial inflow. The resulting compartment syndrome is most common in circumferential extremity burns, but

abdominal and thoracic compartment syndromes also occur. Warning signs of impending compartment syndrome may include paresthesias, pain, decreased capillary refill, and progression to loss of distal pulses.

Abdominal compartment syndrome should be suspected with decreased urine output, increased ventilator airway pressures, and hypotension.

Hypoventilation, increased airway pressures, and hypotension may also characterize thoracic compartment syndrome.

Escharotomies are rarely needed within the first 8 hours following injury and should not be performed unless indicated because of the terrible aesthetic sequelae. When indicated, they are usually performed at the bedside, preferably with electrocautery to minimize blood loss.

Extremity incisions are made on the lateral and medial aspects of the limbs in an anatomic position and may extend onto thenar and hypothenar eminences of the hand.

Digital escharotomies do not usually result in any meaningful salvage of functional tissue and are not recommended. Inadequate perfusion despite proper escharotomies may indicate the need for fasciotomy, but this procedure should not be routinely performed as part of the eschar release.

Thoracic escharotomies should be placed along the anterior axillary lines with bilateral subcostal and sub-clavicular extensions. Extension of the anterior axillary incisions down the lateral abdomen typically will allow adequate release of abdominal eschar.

The strategy of early excision and grafting in burned patients revolutionized survival outcomes in burn care. Not only did it improve mortality, but early excision also decreased reconstruction surgery, hospital length of stay, and costs of care.[83]

Once the initial resuscitation is complete and the patient is hemodynamically stable, attention should be turned to excising the burn wound. Burn excision and wound coverage should ideally start within the first several days, and in larger burns, serial excisions can be performed as patient condition allows. Excision is performed with repeated tangential slices using a Watson or Goulian blade until viable, diffusely bleeding tissue remains. It is appropriate to leave healthy dermis, which will appear white with punctate areas of bleeding.

Excision to fat or fascia may be necessary in deeper burns. The downside of tangential excision is a high blood loss, though this may be ameliorated using techniques such as instillation of an epinephrine tumescence solution underneath the burn.[84]

For patients with clearly deep burns and concern for excessive blood loss, fascial excision may be employed. In this technique, electrocautery is used to excise the burned tissue and the underlying subcutaneous tissue down to muscle fascia. This technique markedly decreases blood loss but results in a cosmetically inferior appearance due to the loss of subcutaneous tissue.

For excision of burns in difficult anatomic areas, such as the face, eyelids, or hands, a pressurized water dissector may offer more precision but is time consuming, has a steep learning curve, and is expensive.[47]

2.9.12. WOUND COVERAGE

Since full-thickness burns are impractical for most burn wounds, split-thickness sheet autografts harvested with a power dermatome make the most durable wound coverings and have a decent cosmetic appearance.

In larger burns, meshed autografted skin provides a larger area of wound coverage. This also allows drainage of blood and serous fluid to prevent accumulation under the skin graft with subsequent graft loss. Areas of cosmetic importance such as the face, neck, and hands should be grafted with non-meshed sheet grafts to ensure optimal appearance and function.

Sometimes, extensive meshing of skin grafts in patients with limited donor sites may not provide adequate amounts of skin and for this reason, one emerging technique for large burns with limited donor sites is the Meek micrografting technique, or “postage-stamp” technique, where expansion ratios of up to 9:1 are able to be achieved.

Options for temporary wound coverage include human cadaveric allograft, which is incorporated into the wound but is rejected by the immune system and must be eventually replaced.

This allows temporary biologic wound coverage until donor sites heal enough so that they may be re-harvested.

Xenograft appears to function as well as allograft for temporary wound coverage and is considerably less expensive.

Some dermal substitutes such as synthetic skin should also be used in combination with thin split-thickness skin grafts for final wound coverage.[47]

Epidermal skin substitutes such as cultured epithelial autografts are an option in patients with massive burns and very limited donor sites.[85]

Their clinical use has been limited by a long turnaround time for culturing, as well as the fragility of the cultured skin, which creates great difficulty with intraoperative handling and graft take.

Thighs make convenient anatomic donor sites; they are easily harvested and relatively hidden from an aesthetic standpoint.

The buttocks are an excellent donor site in infants and toddlers; silver sulfadiazine can be applied to the donor site with a diaper as coverage. The scalp is also an excellent donor site; the skin is thick and the many hair follicles allow rapid healing, with the added advantage of being completely hidden once hair regrows. Epinephrine tumescence is necessary for harvesting the scalp, for both haemostasis of this hyper-vascular area and also to create a smooth contoured surface for harvesting.

The list of commonly used donor site dressings is long and includes simple transparent films to hydrocolloids, petrolatum gauzes, and silver-impregnated dressings.

Principles behind choosing a dressing should balance ease of care, comfort, infection control, and cost. The choice of donor site dressing is largely institution dependent, and few data support the clear superiority of any single treatment plan.[47]

2.9.13. REHABILITATION

Rehabilitation is an integral part of the clinical care plan for the burn patient and should be initiated on admission. Immediate and ongoing physical and occupational therapy is mandatory to prevent functional loss. Patients who are unable to actively participate should have passive range-of-motion exercises done at least twice a day.

This includes patients with burns over joints, such as with hand burns. Patients should be taught exercises they can do themselves to maintain full range of motion.

Patients with foot and extremity burns should be instructed to walk independently without crutches or other assistive devices to prevent extremity swelling, desensitize the burned areas, and prevent disuse atrophy; when patients are not ambulating, they must elevate the affected extremity to minimize swelling. If postoperative immobilization is used for graft protection, the graft should be evaluated early and at frequent intervals so that active exercise can be resumed at the earliest possible occasion.

The transition to outpatient care should also include physical and occupational therapy, with introduction of exercises designed to accelerate return to activities of daily living as

well as specific job-related tasks. Tight-fitting pressure garments provide vascular support in burns that are further along in the healing process.

They do provide vascular support that many patients find more comfortable and they prevent hypertrophic scar formation.[47]

Applied to a surgical mission context in LMICs this aspect can be complicated to follow and implement if not intervening through a long-term mission or actively engaging in the teaching and training of local staff.

2.9.14. LATE COMPLICATIONS: HYPERTROPHIC SCAR, CONTRACTURES, AND HETEROTOPIC OSSIFICATION

Once patients have recovered from their acute burns, many face management of the hypertrophic burn scars. In patients with healed burns or donor sites, hypertrophic scar-related morbidity includes pruritus, erythema, pain, thickened tight skin, and even contractures.

Within these scars, there is believed to be an increased inflammatory response, irregular neo-vascularization, aberrant cytokine and Toll-like receptor expression, abundant collagen production, and abnormal extracellular matrix structure.

Treatment for these scars has included nonsurgical therapies such as compression garments, silicone gel sheeting, massage, physical therapy, and corticosteroid. Surgical excision and scar revision represent more invasive scar management approaches that are often necessary for functional and aesthetic recovery.[86]

Contractures are another long-term complication of burn injury that can result in significant morbidity. Contractures result from both wound contracture and scar contracture and prevents range of motion of a particular joint. Factors influencing contracture development include burn depth and activation of dermal fibroblasts, myofibroblasts, fibrocytes, and helper T cells.[47]

Despite aggressive physiotherapy, contractures have been reported to develop in as many as one-third of burn patients.

A recent study of 1865 patients demonstrated that the shoulder is the most affected joint, followed by the elbow, wrist, ankle, and knee.[87] A similar study in the paediatric population yielded similar results. Gender, race, and %TBSA were associated with contracture development in the adult population. Age and length of stay in the ICU were

associated with contracture development, severity of contracture, and total number of contractures in the paediatric population.

Treatment of contractures includes both nonsurgical and surgical options, ranging from pressure garments and splints to laser therapy and contracture excision.

Heterotopic ossification (HO) is another long-term morbidity associated with burn injury. HO is the pathologic development of lamellar bone in peripheral tissue. Its incidence has been reported to be between 1% and 3% of burn patients.[88]

Symptoms include decreased range of motion, pain, and swelling overlying the affected joints. Often times, the pathologic bone formation can be visualized radiographically with plain X-rays.

Risk factors include >30% TBSA, arm burns, arm grafts, ventilator days, and number of trips to the operating room. Treatment includes aggressive physiotherapy, NSAIDs, bisphosphonates, radiation therapy, and rarely surgical excision. A risk scoring system has been developed to predict which burn patients are at risk of developing HO based on admission criteria; however, further validation is warranted.[89]

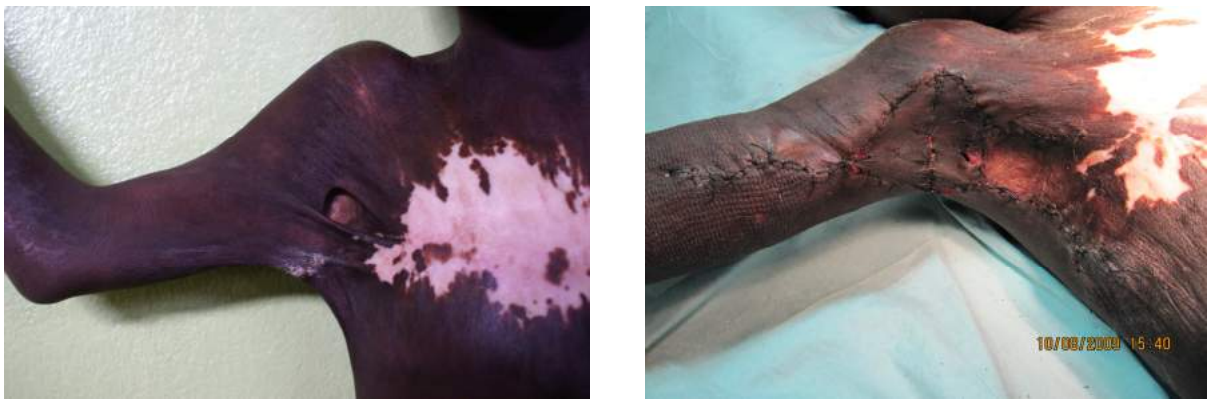


Figure 21. Scar from burn late complication. Case operated by FES Fundació team in 2009.

2.9.15. PSYCHOLOGICAL RECOVERY

Psychological rehabilitation is equally important in the burn patient. Depression, posttraumatic stress disorder (PTSD), concerns about image, and anxiety about returning to society constitute predictable barriers to progress in both the inpatient and outpatient setting. Psychological distress occurs in as many as 38% of burn patients and persists in severity long after discharge.[90] Rates of depression vary between 4% and 54% following

injury, although these numbers vary dramatically based on the methodology used to diagnose depression.[91]

Still, depressive symptoms have been documented in up to 43% of patients 2 years following injury and have been associated with the female gender. Factors such as gender, extraversion, capacity for forgiveness, the event as a disaster or non-disaster, have been identified as contributing factors to PTSD.[92]

Despite the psychological impact of burn injury, many patients will be able to quickly return to work or school, and goals should be set accordingly.

2.9.16. PREVENTION

Despite many areas of progress in prevention over the past century, burns continue to be a common source of injury. The cornerstone for burn prevention programs has been "The Five Step Process," a systematic method of assessing, implementing, and evaluating burn hazards and subsequent intervention impact, and *The Five E's* (engineering/environment, enforcement, education, emergency response, and economic initiative).[93]

It has been shown that patients who live in environments optimal for sustaining burn injury have decreased knowledge of burn prevention strategies.[94]

Some successful initiatives have included school-based education and community-based interventions targeting simple home safety measures. A 6-year study of second-graders demonstrated both short- and long-term retainment of information related to burn, fire, and life safety following multiple educational sessions.

A recent systematic review of prevention in LMICs identified multiple successful prevention programs.[95]

3. METHODS

As previously mentioned, the need for the study arises from the desire to understand what are the possibilities and needs of paediatric surgery applied to global health.
Certainly, data in the literature are already present, even if scarce, and there is no pretext to make changes to what has already been analysed.
However, it stems precisely from a recognition that the traces of missions are often partially lost without then being applied to a context of common knowledge.
The aim is therefore to understand if the missions at our "fingertips" can satisfy, even partially, what are the objectives of global health and if the analysis of the statistical data ordered according to some criteria can be in line with scientific literature and make a small contribution to better directing efforts and future studies in this area.

First of all, we asked ourselves, from which missions we could draw the data that best suited us. We therefore opted for a study based on a multicentric analysis, which could range both geographically as regards the countries of destination of the missions, and in the experiential field.
Having opted for the contribution that the Paediatric Surgery Department of Ferrara could make to the knowledge in the field, given the many years of diversified experience in developing countries, the study was based on the analysis of the main missions implemented by the Paediatric Surgery Department of Ferrara and by the same in collaboration with various NGOs (also verifying the importance of close collaboration between the various organizations for the development of a more comprehensive overall health in its various aspects).
The multi-year experience of a Spanish cooperative reality has also been integrated. It is an NGO in which a doctor (Dr Manuela Corradini) from the Paediatric Surgery Department of Ferrara has served several times.
Therefore, the data derive from:

- Paediatric Surgery Department of Ferrara
- *Chirurgo e Bambino Onlus*
- *Smile Train Italia*
- *Operation Smile Italia*
- *Fes Fundació*

In the first instance, the data of the overall numbers of the interventions carried out in each mission were collected.
They were then divided by country and year in which the missions were carried out.
The work was partially complex as the various NGOs collected their data in different databases, often giving importance to different factors not commonly recorded by the various organizations and therefore not precisely reported in the study, including:

- age of the patients (sometimes unknown for personal data),
- ratio of patients visited to patients undergoing a surgical procedure,
- number of operations per day,
- specific techniques used for each operation,
- type, area, extent and depth of burns in burn patients.

We therefore focused on the number of surgical procedures sustained.
The data were then divided by intervention classes according to the aetiology of the pathologies, in line with those which are the macro areas mainly present in scientific literature:

- Congenital conditions
- Malignancies
- Injuries
- Other (in turn composed by Surgical Infections and Other)

Subsequently, the number of missions carried out by the various organizations in each recipient country was then assessed:

- Armenia
- Ethiopia
- Kenya
- Peru
- Siberian Federal District
- Tanzania

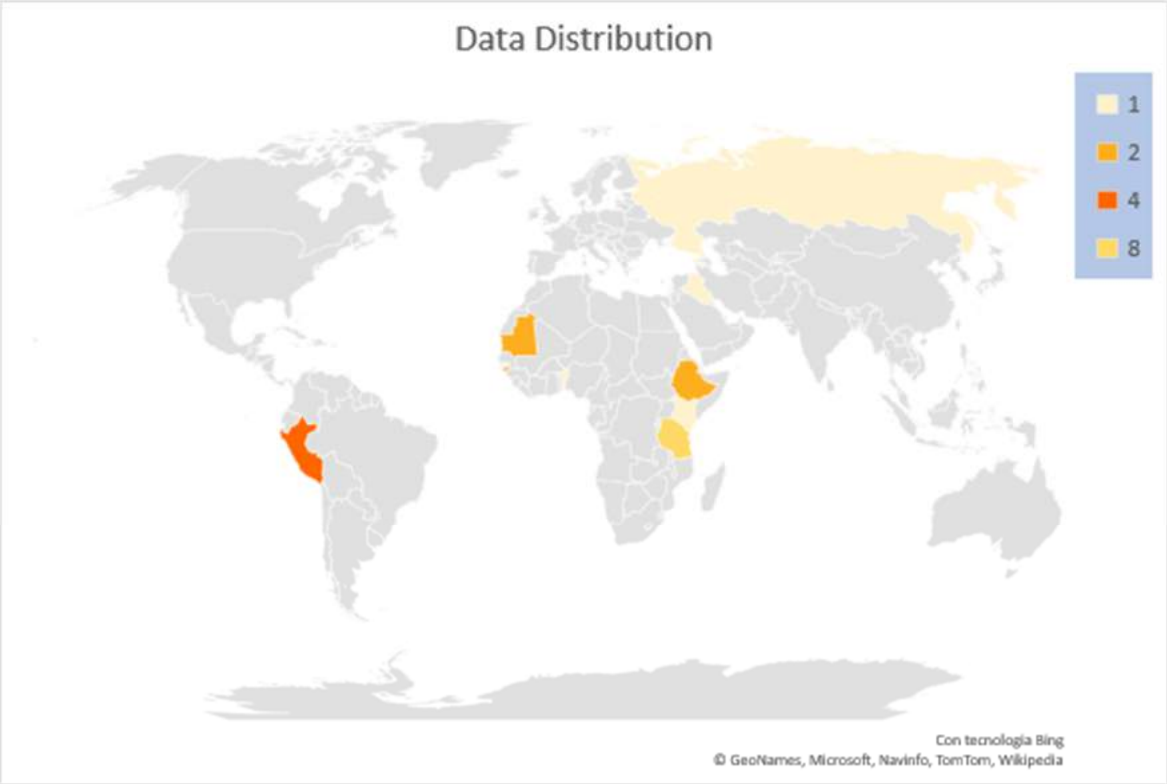
- Iraq
- Benin
- Mauritania
- Guinea-Bissau

For all the data collected per year, we have recreated a graphic display.
Then we focused on the statistical analysis of all the data overall. In this passage, however, it was decided to exclude the only long-term mission analysed by us. The choice is due to the fact that the time spent on missions by operators is substantially different (about six months) compared to the time spent on short-term missions. For this reason, the data collected could be totally different from that collected in short-term missions. As for the long-term mission (Kenya 2004 of Paediatric Surgery Department of Ferrara), we have built a separate statistical analysis.

Although we know that the data analysis of our study is purely qualitative, we are interested in understanding the variance of the same. We then calculated the weighted standard deviation of the missions for all organizations overall.
In this way we were able to understand how effectively the percentages of the various analyses varied. Noting immediately the large gap between the various associations regarding the standard deviations, it was decided to group the study of the standard deviations weighed into two groups.
The first group was composed of the weighted percentages of the interventions carried out in the missions of *Operation smile Italy* and *Smile train Italy*. The second group was composed of *Chirurgo e Bambino Onlus* and *FES Fundaciò* Missions.
These groupings are due to the fact that from the data, it was noticed almost immediately that the gap between the "interests" of the different organizations was evident. The standard deviations in fact showed how the first group was more willing to operate on patients with congenital pathologies than the second, characterized by much lower percentages of variability compared to the second group.

Below there is a graph showing the number of missions analysed by us and their geographical location.

In fact, it seemed interesting to have a material visualization of the geographical distribution of the humanitarian missions analysed by us.



Graphic 1. Geographical distribution of surgical missions analysed by us.

Ultimately, we asked ourselves how the number of interventions, grouped in the macro-groups of pathologies, varied with the course of time. We then moved towards the temporal analysis of the various humanitarian missions analysed. The greatest difficulty arose in the absence of a constant succession of missions of the various organizations on a purely annual basis.

Furthermore, another difficulty was found in the lack of sufficient numbers per year. Here, only the years in which two or more surgical missions were detected were included in the temporal analysis. In this way there was enough data per year. The years entered are therefore 2007, 2009, 2011, 2015, 2016, 2017, 2019.

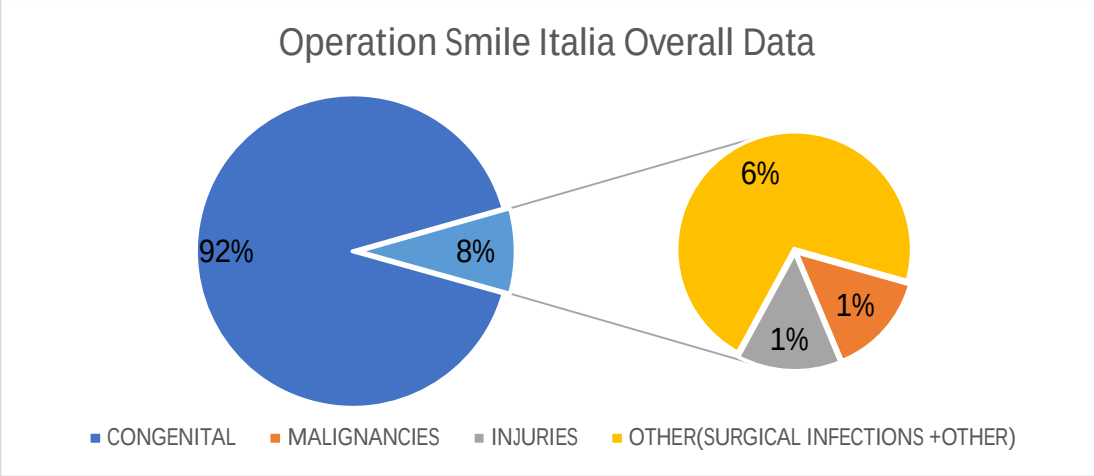
The temporal analysis of the missions of the individual *Chirurgo e Bambino Onlus* organization was then carried out. This choice was chosen for two reasons. The first one, is that from a merely quantitative point of view we had a substantial number of missions belonging to this organization, and consequently we had sufficient data distributed over the years to start a temporal analysis.

The second is that precisely for this large number of missions distributed over time, with a sustained trend, belonging to one organization (with constant objectives and statutes), it has become interesting to evaluate whether the data actually remained constant.
We now move on to the treatment of the data with the relative graphs and to their analysis.

4. DATA ANALYSIS

	Siberia	Armenia	All Missions	All Mission %
YEAR	2005	2006		
CONGENITAL	49	24	73	91%
MALIGNANCIES	1	0	1	1%
INJURIES	0	1	1	1%
OTHER	5	0	5	6%
TOTAL CASES	55	25	80	100%

Table 3. Total cases of Operation Smile Italia in all selected surgical missions by us.



Graphic 2. Percentage of Operation Smile Italia Overall Data.

By analysing the data collected by the collaboration of the Paediatric Surgery Department of Ferrara with Operation Smile Italia, we can see the presence of a 92% of surgical congenital conditions. They therefore cover most of the operations that took place in the two missions, leaving aside a minimum percentage (8%) of other faced pathologies, among which we find 1% of injuries, 1% of malignancies and finally 6% is made up of those operations which in the study (see above) are grouped together as other.

In these two missions (Siberia in 2005 and Armenia in 2006), the data remained mostly unchanged, although there was a drop in surgical performance during the second mission due mainly to logistical issues.

The tables with the data of the individual items are shown in the Appendix (Table n.13).

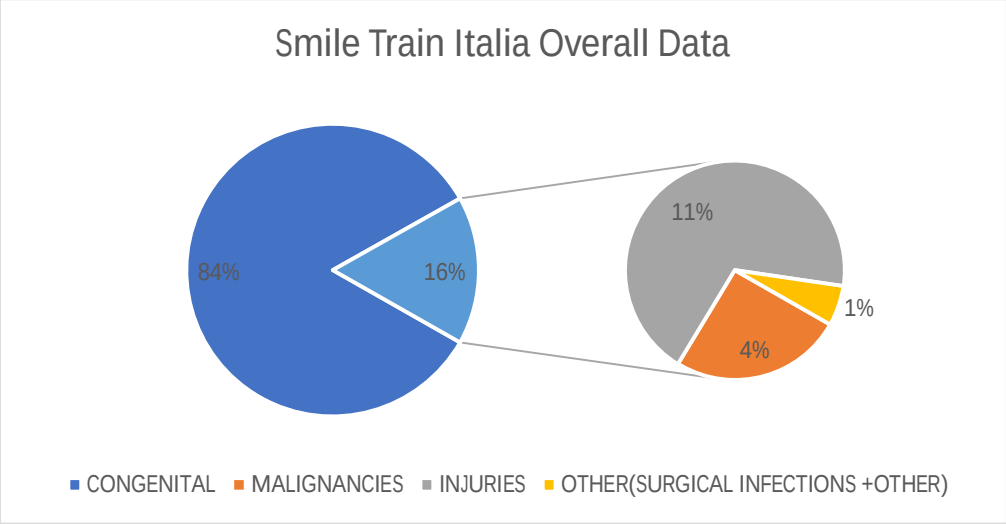
What can obviously be seen is a significant imbalance in the number of cases in the area of congenital pathologies, and more precisely unilateral lip repair operations were carried out

(respectively 6 in Siberia and 8 in Armenia) and cleft palate repair , especially during the mission in Siberia.

This allows us to highlight and anticipate what will often be seen in the subsequent data, namely the presence of an imbalance with regard to certain pathologies, which mainly derives from two factors. The first one is given by the natural epidemiology of these pathologies at a global level and especially in LMICs, the other one is derived from a very high specialization of organizations and from the particular and different purposes that the various organizations set themselves.

	Tanzanian	Tanzanian	Ethiopia	Iraq	Benin	ALL Mission	All Mission %
YEAR	2007	2009	2009	2011	2011	ALL	
CONGENITAL	44	35	48	114	19	260	84%
MALIGNANCIES	0	1	2	8	2	13	4%
INJURIES	25	4	4	1	1	35	11%
OTHER	1	1	1	0	0	3	1%
TOTAL CASES	70	41	55	123	22	311	100%

Table 4. Total cases of Smile Train Italia in all selected surgical missions by us.



Graphic 3. Percentage of Smile Train Italia Overall Data.

By analysing the data collected by the collaboration of the Paediatric Surgery Department of Ferrara with *Smile Train Italia*, from 2007 to 2011, we can see the presence of 84% of surgical congenital conditions operations. They therefore cover most of the operations that

took place in the five missions, leaving aside a bigger percentage (16%) of other faced pathologies then the percentage detected by the two missions in collaboration with operation smile. Among the remaining operations that can be seen from the graph, we find 11% of Injuries, 4% of Malignancies and finally 1% is made up of those operations which in the study (see above) are grouped together as Other.

To note the notable presence in the Table n. 4 of the operations that took place due to congenital conditions in the mission in Iraq in 2011, such a considerably high number is due to a strong organizational capacity, logistics, the high number of paediatric surgeons and healthcare personnel involved in the missions and in teams.

This concept too, given the initial premise in the introduction that dealt with the number of paediatric surgeons present in the LMICs territories, will subsequently be addressed with all the data analysed.

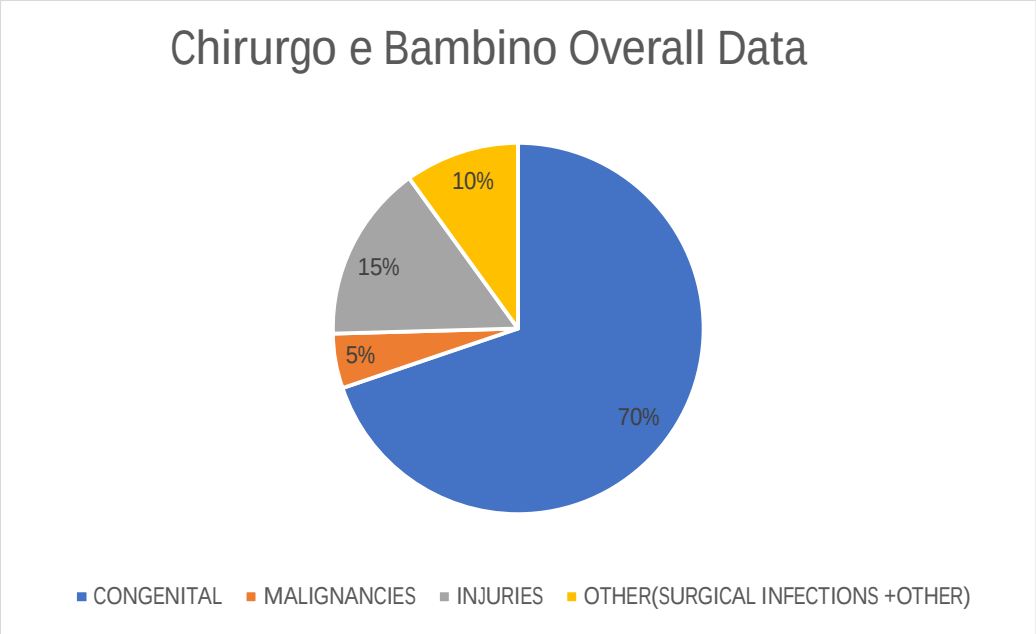
However, in addition to this uncommon peak in the data of these missions, the data demonstrate an almost unchanged qualitative distribution. Even within the mission in Iraq, the operations performed for pathologies not grouped in the congenital ones, reflect a trend comparable to that of the other missions.

	Mauritanian	**Mauritan**	**Tanzanian**	**Tanzanian**	**Tanzanian**	**Tanzanian**	**Guinea B.**	**Guinea B.**	**Guinea B.**	**Tanzanian**	**Tanzanian**
YEAR	2007	2009	2015	2015	2016	2016	2017	2017	2018	2019	2019
CONGENITAL	7	9	51	55	60	48	6	11	13	15	5
MALIGNANCIES	0	5	3	1	0	0	2	1	6	0	1
INJURIES	11	7	8	2	8	7	2	2	10	5	0
OTHER	3	0	3	4	8	8	2	1	9	1	1
TOTAL CASES	21	21	65	62	76	63	12	15	38	21	7

Table 5. Total cases of Chirurgo e Bambino Onlus in all selected missions by us.

	All Missions	All Mission %
CONGENITAL	280	70%
MALIGNANCIES	19	5%
INJURIES	62	15%
OTHER	40	10%
TOTAL CASES	401	100%

Table 6. Cases and percentages of Chirurgo e Bambino Onlus in all selected missions by us.



Graphic 4. Percentage of Chirurgo e Bambino Onlus Overall Data.

By analysing the data collected by the *Chirurgo e Bambino Onlus* from 2007 to 2019, we can see the presence of 70% of surgical congenital conditions operations. They therefore cover most of the operations that took place in the five missions, leaving aside a large percentage (30%) of other faced pathologies.

Among the remaining operations that can be seen from the graph, we find 15% of injuries, 5% of malignancies and finally 10% is made up of those operations which in the study (see above) are grouped together as other.

As is clear now, the highest percentage of implemented interventions that have proven over the years are the interventions aimed at constituting a resolution for congenital pathologies. In detail Unilateral or Bilateral Lip Repair, Lip and Palate cleft repair, Revisions of Palatal Closure, Nasal deformity Correction, Circumcisions, Hypospadias Surgery, Orchidopexy, Treatment of Anorectal Malformations such as Imperforate anus or Recto-vestibular Fistulae, Syndactyly release, treatments of Inguinal Hernias, Umbilical Hernias,

Onphaloceles and treatments of Myelomeningocele (To view more details, see table number 15A-B in Appendix).

The fact that in this graphic appear in greater numbers than the other graphs analysed previously, interventions not only aimed at improving congenital conditions, highlights the phenomenon that in LMICs the distribution (although epidemiologically greater in these regions) of congenital pathologies is not totalizing, but partially balanced with other pathologies.

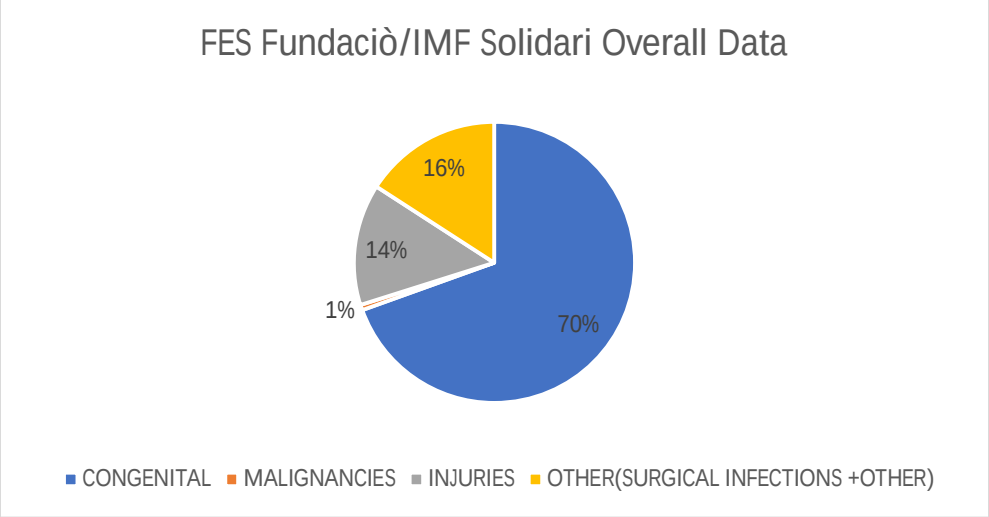
Once again, it is evident that organizations that provide healthcare services in LMICs often have very specialized tasks and wishes, which sometimes only partially cover the needs of the local paediatric population.

However, this aspect (which will be further analyzed below) does not preclude the efficiency of short-term missions organized by this type of organization.

Another factor that leads to a balance of the pathologies treated, in addition to that of a wider view of the organization itself, is that the missions analysed are in greater numbers (see Table n.6), thus having a larger sample for obvious reasons.

	Ethiopia	Peru	Peru	Peru	Peru	All Missions	All Mission %
YEAR	2009	2011	2012	2013	2014		
CONGENITAL	18	19	26	27	24	114	70%
MALIGNANCIES	1	0	0	0	0	1	1%
INJURIES	14	0	7	0	2	23	14%
OTHER	5	7	6	8	0	26	16%
TOTAL CASES	38	26	39	35	26	164	100%

Table 7. Total cases of FES Fundaciò in all selected missions by us.



Graphic 5. Percentage of FES Fundaciò Overall Data.

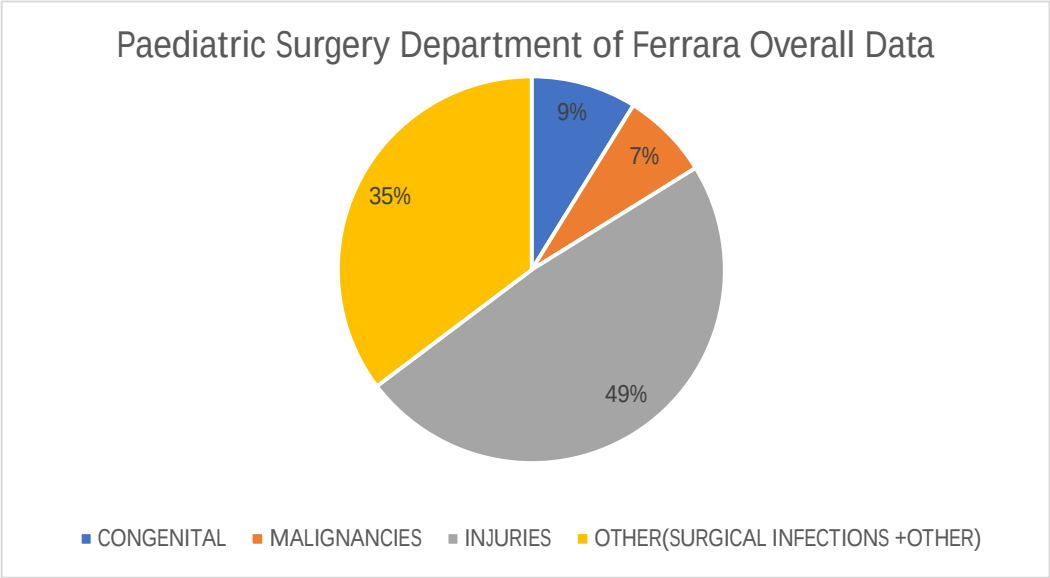
By analysing the data collected by *FES Fundació* surgical missions, we can observe the presence of a 70% of operated surgical congenital conditions. They therefore cover most of the operations that took place in the five missions from 2009 to 2014, leaving aside a percentage (31%) of other faced pathologies, among which we find 14% of injuries, 1% of malignancies and finally 16% is made up of those operations which in the study (see above) are grouped together as other.

In this case too, with a qualitative analysis of the data taken into consideration, we can argue that the numbers probably reflect those present in the literature.

In this case, a smaller number (compared to *Operation Smile Italia* and *Smile Train Italian* analysed missions) of pathologies on a congenital basis operated on site, and an increase in the remaining ones (Malignancies, Injuries, Other) due to the fact that the organization's objective is centred on a more diversified set of aspects. In fact, the organization is made up of multi-disciplinary teams at each mission aimed, also at a more complete vision in the treatment of pathologies that it encounters on site, albeit more at maxillofacial surgery. Thanks to close collaboration with local NGOs and local organizations operating on the territory, characterized by a greater and marked knowledge of the local population and the possibility of approaching it, FES Fundació can count on a greater response to the paediatric surgical needs of the place.

	Kenya	All Mission %
YEAR	2004	
CONGENITAL	6	9%
MALIGNANCIES	5	7%
INJURIES	33	49%
OTHER	24	35%
TOTAL CASES	68	100%

Table 8. Total cases of Paediatric Surgery Department of Ferrara surgical missions by us.



Graphic 6. Percentage of Paediatric Surgery Department of Ferrara Overall Data.

By analysing the data collected during the long-term paediatric surgical mission in Kenya in 2004 of the Paediatric Surgery Department of Ferrara, we can qualitatively analyse a significant change in the distribution of surgical interventions over the six months. The most important and relevant percentage, which consists in 49% is covered by Injuries requiring surgical treatment and most are treated burns.

The second largest percentage (35%) consists mainly of the item that in the study we call *Other*. These percentages are then followed by a 9% of operations aimed at resolving congenital pathologies and an 8% of neoplastic excision operations.

We are aware the fact that the number of data available to us is not adequately sufficient for the deduction of any phenomenon.

From a superficial view of these latter data, it is possible to notice a total phase shift compared with those collected in the other missions. However, the substantial difference that can be seen derives from the fact that the mission was carried out over a prolonged time period, in which the needs achieved were diversified. For details see the Table n.17 in Appendix.

If we analyse the weighted average of the percentages of the surgical interventions adopted in all the long-term missions, we can observe that our data are distributed in a similar way to the data present in the specific literature concerning the analysis of the needs of paediatric surgery in LMICs present in the article *The burden of paediatric surgical conditions in low and middle income countries: A call to action.*[12]

We can indeed observe that our sample is close to literature, and in this sense, we can consider it significant.

The percentages, with a simple numerical comparison, do not differ much from those present in the graphic of *Distribution of causes of total and surgical burden of disease globally* (Fig. 1) although the weighted standard deviation of the percentages of the intervention classes of all the missions analysed, except the long-term one of 2004 of the Ferrara department, are not indifferent from the point of view of variability (16%).

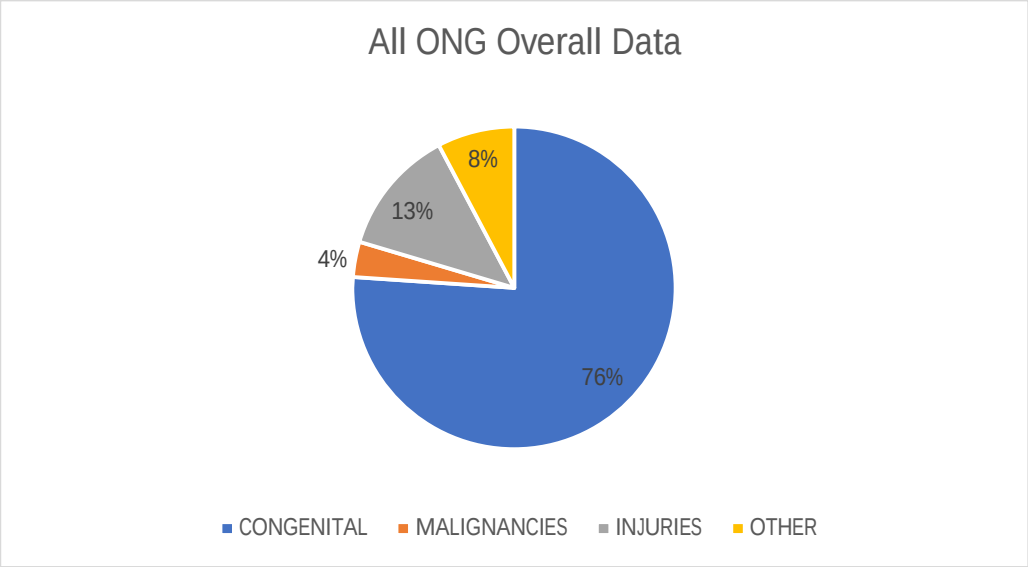
This derives from the fact that most of the various missions analysed belong to different organizations, which in turn have different objectives.

However, it should be noted that the pathologies treated fall with a certain constant and without making a big difference appear.

By simply looking at our data, we cannot fail to notice that the percentage distribution present in the literature comes closest actually to the only long-term mission analysed by us. It is evident from our data that the very nature of the missions (long term / short term) brings the percentages closer or less to those of the literature.

	ALL NGOs	ALL NGOs %	Weighted Standard Deviation
CONGENITAL	727	76%	16%
MALIGNANCIES	34	4%	5%
INJURIES	121	13%	13%
OTHER	74	8%	17%
TOTAL CASES	956	100%	/

Table 9. Total cases, percentages and Weighted Standard Deviation of all NGOs surgical missions selected by us.



Graphic 6. Percentage of All NGOs Overall Data.

This can be seen by going numerically in different ways to observe the weighted standard deviations by grouping the organizations by "field of interest" (Table n.10).

In fact, we note how the weighted standard deviations between the *Smile Train Italia-Operation Smile Italia* missions grouping are 1% for Congenital conditions, 1% for operated Malignancies, 3% for Injuries requiring surgical treatment, 2% for Other. The weighted standard deviations between the *Chirurgo e Bambino Onlus-FES Fundació* missions grouping are instead 17% for Congenital conditions, 6% for operated malignancies, 12% for injuries requiring surgical treatment and 7% for other.

The analysis of such a low variability as regards congenital pathologies (especially lip and/or cleft palate) in the first grouping (1%) points out a very high specificity of these organizations in that area. The range of variability in the same area as regards the second grouping is considerably higher (17%) going to highlight the fact that the variability of the interventions in the various missions is high.

	1st Group's Weighted Standard Deviation	**2nd Group's Weighted Standard Deviation**
CONGENITAL	1%	17%
MALIGNANCIES	1%	6%
INJURIES	3%	12%
OTHER	2%	7%

Table 10. Different Weighted Standard Deviations of organizations groups formed by us.

Finally, by looking at our data in a temporal perspective, we can again affirm what follows. The temporal analysis of our data does not lead to reveal different considerations compared to what has already been stated during all our study.
The study of the temporal trend was born from the awareness that the missions can have a certain variability in the number and type of cases and surgery performed.
However, what appears evident is that the trend does not differ from the interpretation of the data that has already taken place. In fact, what you notice are mainly three phenomena.
The first is a large quantity of interventions aimed at the surgical resolution of congenital conditions (Blu Line in Graphic n.7). The second one, is that there is a constant on high values of the number of surgical operations performed for congenital conditions. Finally, the third, you can observe a flattening of the other three curves (Orange line, Grey line and yellow line in Graphic n.7) constantly on the lowest values of the graph. This implies the presence of small numbers in the overall temporal trend, of the types of surgical operations remaining.
This brings out what has already been observed: a presence in our data, compared to short-term missions, of a numerical prevalence of interventions in children with congenital pathologies.
At this point, it is very important to specify at this point, that the numerically high presence of this kind of surgical interventions does not imply the actual numerically high presence of this type of pathologies, nor such an effectively high number on a global scale in LMICs of such pathologies.
We are not going to improperly infer from our data that these numbers can be applied to a unique global health context. We can only verify that, in the context where the organizations which we analysed have served, well-defined surgical needs have been met, sometimes limited, but not for this reason useless for the local paediatric population.

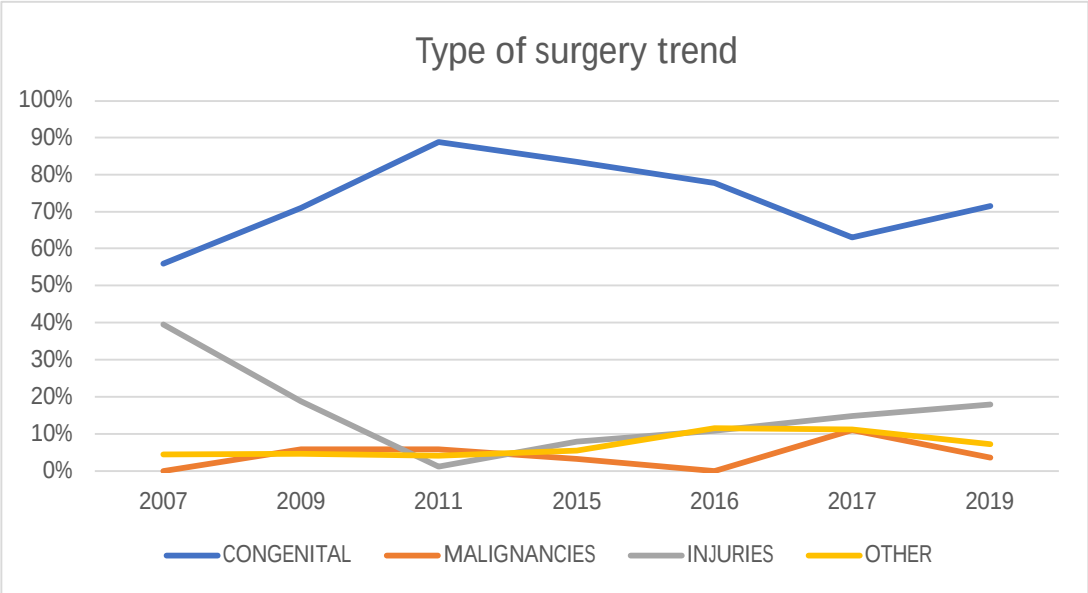
We can now analyse the temporal analysis of *Chirurgo e Bambino Onlus* surgical missions (Graphic Number 8).
The flattening of all four curves certainly goes to demonstrate a constant presence of the various classes of interventions. Analysing the graphic of the temporal analysis of the *Chirurgo e Bambino Onlus* organization we can instead notice how the curves do not have a linear and constant trend. In fact, all four classes have significant variations (especially congenital conditions, and injuries). We can see two distinct phenomena. In 2015 we had

83% of congenital and the remaining percentage was made up of 8% of injuries, 3% of operated Malignancies and 6% of other. Vice versa in 2007 we had 33% congenital, 52% of Injuries requiring surgical treatment, 0% of malignancies, 14% of other and in 2018 we had 34% congenital, 26% of Injuries requiring surgical treatment, 16% of malignancies, 24% of other.

These two phenomena (a significant increase in congenital pathologies operated in 2015, and a reversal in 2007 and 2018) make it clear that there is a considerable variability in the surgical needs of children. Or rather, the organization itself, not having chosen as the main aim to operate children with congenital pathologies, meets surgical needs in a diversified and complete way over the years. In fact, it is normal that different peaks can occur, based merely on what is encountered on the mission site, not precluding the possibility of intervening in all situations.

YEAR	2007	2009	2011	2015	2016	2017	2019
CONGENITAL	56%	71%	89%	83%	78%	63%	71%
MALIGNANCIES	0%	6%	6%	3%	0%	11%	4%
INJURIES	40%	19%	1%	8%	11%	15%	18%
OTHER	4%	5%	4%	6%	12%	11%	7%
TOTAL CASES	100%	100%	100%	100%	100%	100%	100%
Number Cases	91	127	171	127	139	27	28

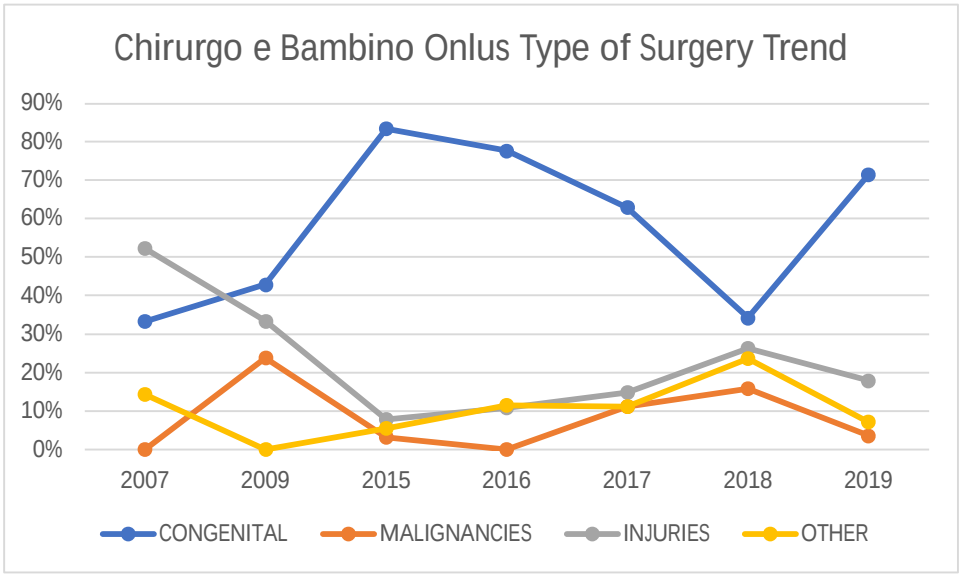
Table 11. Percentage of cases of all NGOs by year.



Graphic 7. Temporal analysis of All NGOs Overall Data.

	Mauritanian	Mauritan	Tanzanian	Tanzanian	Guinea B.	Guinea B.	Tanzanian
YEAR	2007	2009	2015	2016	2017	2018	2019
CONGENITAL	33%	43%	83%	78%	63%	34%	71%
MALIGNANCIES	0%	24%	3%	0%	11%	16%	4%
INJURIES	52%	33%	8%	11%	15%	26%	18%
OTHER	14%	0%	6%	12%	11%	24%	7%
TOTAL CASES	100%	100%	100%	100%	100%	100%	100%

Table 12. Percentage of cases of Chirurgo e Bambino Onlus Missions by year.



Graphic 8. Temporal analysis of Chirurgo e Bambino Onlus Overall Data.

5. DISCUSSION AND CONCLUSIONS

Although acknowledgment of the need for improved access to surgery is now slowly growing, data and knowledge about both the current state of surgical care, as well as best methods for delivering and improving such care, are largely lacking. This information gap is greatest in LMICs and is particularly apparent surrounding the surgical care of children who comprise nearly one third of the population in less developed regions.[96]

However, research priorities for an individual setting should be driven by local clinicians, researchers and change agents, and should be modified to fit the local context and needs of children and families affected by surgical conditions.[36]

However, although this premise is clear for us, the need for studies is always present. We cannot therefore avoid our desire to make such a limited contribution to knowledge in this area.

Although optimal resources for children's surgical care to improve outcomes have been outlined for HICs,[97] these guidelines cannot practically be applied to many low-resource settings and similar broad guidelines for LMICs do not exist.

Confronting our study with research article *Epidemiology of paediatric surgical needs in low-income countries*[98] we can say some interesting observations. In fact, this study combines data from four LMICs to better elucidate the burden of surgical disease in paediatric populations in these LMICs. Overall, there is a high burden of unmet surgical need in the paediatric population of these countries. Nearly 20% of children had a surgical need, and 62% of those children had at least one unmet surgical need. Extrapolating these estimates to the current paediatric populations in the four countries equates to an estimated 3.7 million children in need of a surgical care.[99]

We have to reiterate the concept that while historically surgery has been deemed too resource intensive to merit significant investment, selected paediatric surgical interventions such as cleft lip or palate repair ($48/disability adjusted life year [DALY] averted), general surgery ($82/DALY averted), or hydrocephalus repair ($108/DALY averted) are similarly cost-effective compared to antiretroviral therapy for HIV ($550/DALY averted) or BCG vaccine for prevention of tuberculosis ($120/DALY averted).[14]

The global health community as well as local governments must make investments in improving access to surgical care to close the gap of unmet surgical need among children in LMICs.

Existing data indicates severe shortages in surgical, anaesthetic, and obstetric providers in LMICs[99] with over 1 million positions unfilled. Thus, current provision of paediatric surgical care in these low-income countries is generally limited to general medical officers and general surgeons. These surgeons practice predominantly within large tertiary care facilities, which a large portion of the population is unable to reach.[100]

In the study cited for comparison, wounds, burns, and extremity conditions were more likely to be treated compared to congenital deformities, abdominal conditions, or head and neck conditions. General practitioners can meet much of the paediatric surgical need including burns, wound debridement, and suturing. However, conditions requiring more specialized care, such as congenital deformities, tumours, and complicated burns' sequelae require a specialized paediatric surgeon.

There is a large deficiency in trained professionals in paediatric surgical care in areas of great need, with many countries lacking any providers.[36]

In the study cited for comparison, unmet paediatric surgical needs were highest in Sierra Leone, a country with no paediatric surgeons and a surgical physician density of 0.18 per 100,000 people.[101] In addition to provider shortages, there is also a maldistribution of the surgical workforce with most of the doctors concentrated in urban areas.[101] This contributes to a lack of access to surgical care for children due to lengthy travel and poor road conditions. In the study, 78% of children lived in rural areas, highlighting the great need to increase access in remote areas throughout LMICs.

The paediatric population is growing in low-income countries where over 50% of the population is less than 15 years of age. As such, progress in delivery of surgical care will require specifically targeting delivery of paediatric surgical care.

Although some limitations, the cited study is a starting point to identify that there is a large unmet need and investments must be made to increase surgical capacity, decrease barriers to care, and develop innovative solutions to provide paediatric surgical care in these kind of resource limited settings.[98]

Since children represent the future economic engine powering LMICs, the value of investing in paediatric surgery also encompasses the future socioeconomic well-being of LMICs. In order to take advantage of the inherent upside to treating congenital disease at

its inception, research must address the knowledge gaps that currently impede the development of effective care systems.[102]

In recent years, the reality of health cooperation in developing countries is undergoing profound change. In fact, it has been understood that the role of hospital care is a priority compared to the past when primary health care projects were considered primary, and surgery was seen as a costly practice to be reserved for life-saving emergencies, caesarean sections and a few other interventions.

The perception that different health needs and demands are emerging in many LMICs, linked to the evolution of the socio-economic contexts and life habits of the population. This is happening especially also following progressive urbanization, globalization and more easy access to information through television and the internet, in particular of that part that lives in large cities and revolves around reference hospitals, where more qualified care is required than the standards guaranteed in normal peripheral hospitals and "traditional" medicine is gradually abandoning.

The effects of globalization in health care should not be neglected.

On the one hand the globalization allows the knowledge of well-tested clinical and organizational models to be easier and it can promote their diffusion.

On the other hand it must deal with the application in the LMICs of new technologies whose advantages do not always correspond to expectations due to the management problems connected to them (sustainability of costs, access to training courses for the use of tools, maintenance problems related to assistance difficulties, punctuality in supplies, etc.)

It is also evident that scientific and technological innovations arouse great interest in a good part of doctors and nurses in LMICs who aspire to improve their skills and the quality of care given to patients, and for this they wish to collaborate with foreign healthcare staff.

Often, most doctors are trained abroad, mainly Cuba, Russia and Europe, and they prefer to stay in the training Countries. As an example, there is no specialist anaesthesiologist in Guinea-Bissau to date.

In this scenario which is changing, in Africa and in the rest of LMICs , the activity of humanitarian organizations with reference to health cannot continue to be mainly carried out on the territory and / or in small or medium-sized hospitals, who mainly require basic surgery and obstetrics, with sporadic needs for specialist activities.

The need for specialists, both surgical and medical, who can carry out complex operations on the spot-on selected patients, begins to emerge especially at the reference hospitals. In

these places, at the same time it is also possible to organize courses and tutoring aimed at training their doctors until the achievement of real operational autonomy.

As we explained above, plastic surgeons, thoracic or vascular surgeons, paediatric, orthopaedic, maxillofacial surgeons and urologists are non-existent or rare.

The work of the paediatric surgeon in LMICs revolves around three fundamental aspects. The first is related to *professionalism*. The preparation and skills required of a surgeon in an LMIC are the same as those required of him in High-income Countries and the activity must be carried out in compliance with the high-quality standards. The professional must be prepared to deal with particularly advanced clinical situations, because they are not treated promptly at the appropriate time and therefore are of a higher severity than what is normally expected for that type of pathology.

Sometimes he may be faced with scenarios of seriousness, due to incorrect treatment received by the patient in previous years. Furthermore, it should not be forgotten that the surgeon must be prepared to face primary surgery but also to deal with any immediate complications, which local conditions can make particularly fearful and insidious. Furthermore, in dealing with operational decisions, it must take into account the possibilities of care and surveillance in the post-operative period, as well as in the follow-up.

For these reasons LMICs must not be considered absolutely "gyms" for less experienced surgeons, who take the opportunity to gain experience. The level of professionalism of those who work there must be equal to, if not higher than, the levels that are claimed in industrialized countries for professional ethical reasons. From this point of view, it is important that the professional also knows how to stop in those situations in which, due to extreme gravity or lack of local aids, it is particularly risky to perform surgery. Heroic attitudes supported by the thought that "anything you do is better than nothing" are extremely dangerous and ethically incorrect.

As we have often reiterated during the study, the second aspect that needs to be addressed is that of *training*.

Isolated surgery missions, sporadic events, during which children are treated but who leave nothing in terms of educational heritage, are today strongly discouraged. It is essential to transmit your knowledge, both in daily work experience but above all through the organization of theorical-practical meetings with local staff.

Only in this way, and thanks to health cooperation programs that include the training aspect, are the foundations laid for LMICs to begin the journey towards the achievement of their own autonomy, in terms of promoting "good health".

In this perspective, the concept of continuity is particularly important: the parcelling of solidarity initiatives makes the transmission of knowledge less effective and the treatment of children and follow-up less complete.

It is therefore essential that every surgical mission can be part of a project that guarantees continuity of treatment in order to be able to get as close as possible to the quality standards of High-Income Countries.

The third aspect to consider is the *social* and *ethical* one. The paediatric surgeon and each team member must precisely know the socio-cultural context in which he will work and to how far this will influence his work. It is essential to know exactly the level of poverty and malnutrition of the population, to evaluate how this will have a clinical impact on surgical activity, in terms of, for example, a high risk of infection and dehiscence of surgical wounds.

Finally, it is appropriate to always deal, even on a human level, with the patient and his family members, in full respect of their traditions and their concept of illness and death.

It is evident that paediatric surgery in recent years has become increasingly active in terms of health cooperation, reflecting what is now a consolidated trend in many specialist disciplines, both medical and surgical.

The common purpose is to work to develop and implement health cooperation projects, aimed at promoting and developing "good health", making sure that LMICs can, over time, become themselves the promoters and guarantors of their health.

This path moves further and further away from the concept of welfarism, favouring a newer and more evolved form of partnership.

As already mentioned during the study, the contrast between short-term and long-term surgical missions has often been encountered. Both modules have different characteristics. We will examine them, in order to understand that both types of intervention have potential to be enhanced, to make a contribution to the inclusion of paediatric surgery as an integral part of interventions aimed at enhancing global health.

As can be seen from our data, which derive to a very large extent from short-term missions, it can be said that most of the short-term missions are aimed at meeting very specific needs of small patients.

In detail, the most striking examples are unilateral/bilateral lip repair, lip and palate cleft repair, burns scar revisions, skin graft for burns treatment.

There are multiple factors involved that organizations often prefer to use short-term missions. Indeed, organizations prefer a pre-screening of the population they will meet.

This allows professionals to focus concretely and maximally on certain types of pathologies to be treated. This will then develop into a series of interventions inserted in a well-defined operating list and characterized by the highest possible efficiency in terms of time and effectiveness of the interventions. During the pre-screening of the paediatric population, a careful selection of candidate patients will take place, so as to maximize human and material resources for maximum efficiency.

It is fair to argue that short-term missions allow organization to meet some needs and solve them. There are pathologies (such as lip or lip and palate cleft, nasal deformity, syndactyly, orthopaedic pathologies requiring surgical treatment, phimosis) that can be treated in one session during a short-term mission.

Other pathologies instead (such as anorectal malformations, burns treatment, necrotizing fasciitis) are undoubtedly more difficult to deal with. We are not talking about a simple difficulty of the surgery itself, but about the fact that some pathologies (such as anorectal malformations) require different times for the execution. Furthermore, these pathologies, for the resolution itself, require a careful preparatory phase but above all a considerable follow-up over time. Young patients need treatment that cannot be provided only in the short term in which the organization is present in the area, but they do not need to be followed over time.

For this reason, it is clear from our data that in the group of congenital pathologies treated in short-term missions, in reality most of the operations performed are aimed at resolving cleft lip and palate. In fact, this kind of interventions requires, in addition to a single operating time, also an evaluation in a limited time.

In most cases, the intervention, in most cases, leads to the resolution of the pathological picture. The complications are not noticeable, but if present, such as the presence of a nasopalatine fistula, they can be easily reviewed the following year, taking care of the young patient during the following surgical mission.

Having seen our data, we certainly cannot give an ethical or evaluative judgment on the usefulness of short-term missions. There are certainly significant problems regarding the difficulty of meeting most of the needs of the local paediatric population in adequate quantities.

However, we cannot deny that if there had not been an intervention included in the short-term surgical mission, this would have weighed inexorably on the individual's personal history. Here, while honestly and intellectually aware that these critical issues are present, we cannot say that short-term missions are useless or non-resolutive.

Indeed, we must remember that among the advantages for which non-governmental organizations often choose short-term missions, there is the very important and not forgettable factor that it is easier to find professional staff willing to work. In fact, more often organizations will meet professionals willing to spend their time on a humanitarian health mission for a limited time. The reasons lie on the possibility of requesting holidays in the departments of origin, leaves of absence and personal and family commitments.

Another advantage not to exclude short-term missions from the scenario of health cooperation, is that surgery (especially paediatric surgery) lends itself optimally to solving pathological situations in a short time on site. If we think, for example, of vaccination campaigns or clinical activities, it will take longer to wait and wait for a concrete implication of one's work. In addition to the projection of activities over time, greater attention would be required to screen the population on the territory. Purely clinical-type activities require larger human resources deployed on a large scale to meet not as specific needs as surgical ones, thus requiring a more lasting use of time.

As for long-term missions, which appear in our data in a very small way (we have analysed only one) we have fewer observations to make. In addition to putting them almost in sharp contrast with short-term surgical missions, we can focus on one particular aspect. Professionals deployed on surgical missions of this nature will have more time. While looking like a superficial observation, it contains multiple aspects.

In long-term missions, the needs that are most deeply rooted in the area are met. Having more time available means being able to support the local population with an activity more focused on responding to specific needs. By reaching specific needs, such as the first intervention, the treatment of burns since their onset, etc., more lasting and incisive interventions can be established for the resolution of long-term sequelae. Such an accurate response to the surgical needs of the place derives from an insertion of the organization of the territory.

The inclusion includes, in addition to the merely material one, also the cultural and trust type.

The study of local needs is of fundamental importance. From our data, albeit small, we can qualitatively observe the presence of operated congenital conditions such as one unilateral

lip cleft or one case of myelomeningocele. Although there is the presence of congenital pathologies to operate, it can be noted in large part there are injuries requiring surgical treatment (Burns, Trauma and Snake Bites) as indicate in the literature.

In addition to surgical interventions aimed at solving particular pathological pictures (such as the congenital conditions or injuries requiring surgery treatment), larger projects can be started (and sometimes concluded) during missions of this type. In fact, it is possible to detect needs that were not thought of before departure, or the surgical needs themselves (while maintaining a constant as we have well observed from the literature) can vary on the way. These missions can therefore also undergo significant changes during their course.

In addition, the training activities of the local staff can be implemented in a more constant, gradual and structured way.

The possibility of involving local professionals from other centres is also interesting, in order to lay the foundations for collaboration and a lasting network aimed at meeting the surgical needs of the local paediatric population.

In conclusion, not being able to unbalance the judgment, and not being able to draw analytical conclusions given our poorly descriptive data on many aspects, we can say that paediatric surgery has a significant and necessary application in LMICs. Indeed, we cannot draw back from the need to include paediatric surgery in the aspects of international cooperation.

We must and we propose to make an even greater effort to go to a further step. Seen and established the lack of workforce, in all fields of paediatric surgery in LMICs (Surgeons, Anaesthesiologists, Nurses), the goal of global health should be to include the strengthening and training of structures as a pillar of the same of paediatric surgery. We do not underestimate the importance of the work of NGOs or bilateral partnerships, but the governments of the LMICs themselves must be required to provide constant training in this regard. Too often the surgical needs of children in LMICs have been and are underestimated. The evolution must therefore be understood in the sense of the inclusion of paediatric surgery in the assessments of the Bourden of Disease going to create the conditions for lasting health, starting with the child, the individual and the community.

For this reason, we can clearly and undoubtedly state that paediatric surgical activity, in order to meet global health needs, must be included as an integral part of LMICs care. Indeed, it is not enough to hope that the promotion of health in LMICs can be relegated to cooperation activities that are already well known as functional to the health of the citizen and the local community. The not indifferent weight of an untreated paediatric surgical

pathology, which is transmitted over the entire life of the individual in terms of quality of life, will have a response in economic and social terms on a par with those tropical pathologies now cleared by customs in the collective imagination of the poor country. A concrete effort must be applied on several levels, aware that only a happy and healthy child can become an adult capable of providing the community in all its aspects.

The pathologies of the child that can be treated surgically, especially congenital (but also sequelae of traumas or sequelae of previous surgical interventions), inevitably preclude a physiological development of the individual. We do not stop only at the state of health as absence of disease, but we must strive to observe the individual as an integral part of a microcosm that is its existence, and a macrocosm that is the community to which it belongs, often fragile both due to a precarious weak or inefficient socio-health-cultural-economic context. A pathology not addressed now will affect tomorrow. In fact, it will have an impact on both biological and cultural growth.

The untreated child will have more difficulty accessing schooling, the world of work and often accepting the community to which he belongs. What must be engaged with an active and systematic study is the development and integration of paediatric surgical practices, beyond the preconceptions and prejudices in all those deficient health systems, bringing high standards of care everywhere.

Surgical missions will not suffice in the near future, unless accompanied by specific training courses. With all limitations, short and long-term missions must not be abandoned, because it is the only way to an approach that will see its development in the radicalization of surgery, and above all of paediatric surgery, in those countries where the social context economic is more needy.

6. APPENDIX

SURGERY INTERVENTIONS Smile Train Italia	Siberia	Armenia
	2005	2006
CONGENITAL		
Unilateral Lip Repair	6	8
Bilateral Lip Repair		1
Lip Scar Revision	15	6
Lip palate cleft Repair		
Palate Rapair	17	3
Palatal Fistula Closure(Revision)	11	6
Alveolar Surgery		
Frenulum Lysis		
Nasal Deformity Correction		
Circumcision		
Hypospadias Surgery		
Orchidopexy		
Anorectal Malformation		
Rectovestibular Fistulae		
Minor Lips Synechiae		
Syndactyly Release		
Inguinal Hernia		
Umbilical Hernia		
Onfalocele		
Visceral Surgery		
Myelomeningocele		
MALIGNANCIES		
Neoplasia Excision	1	
INJURIES		
Burn Scar Release		1
Scar revision/Z-plastic		
Skin Graft		
Abscess Incision		
Snake Bite		
OTHER(SURGICAL INFECTIONS +OTHER)		
Orthopeadic Surgery		
Other	5	
TOTAL CASES	55	25

Table 13. Total cases of Operation Smile Italia in all selected missions by us.

SURGERY INTERVENTIONS Smile Train Italia	Tanzanian	Tanzanian	Ethiopia	Iraq	Benin
	2007	2009	2009	2011	2011
CONGENITAL					
Unilateral Lip Repair	22	13	18		10
Bilateral Lip Repair	2	1	5		2
Lip Scar Revision		1			1
Lip palate cleft Repair				114	
Palate Rapair	4	7	9		4
Palatal Fistula Closure(Revision)			1		1
Alveolar Surgery		3	8		
Frenulum Lysis			1		
Nasal Deformity Correction	16	8	6		
Circumcision					
Hypospadias Surgery					
Orchidopexy					
Anorectal Malformation					
Rectovestibular Fistulae		1			
Minor Lips Synechiae					
Syndactyly Release					
Inguinal Hernia					
Umbilical Hernia					
Onfalocele		1			1
Visceral Surgery					
Myelomeningocele					
MALIGNANCIES					
Neoplasia Excision		1	2	8	2
INJURIES					
Burn Scar Release			2	1	
Scar revision/Z-plastic	15	3	1		1
Skin Graft	9				
Abscess Incision	1				
Snake Bite		1	1		
OTHER(SURGICAL INFECTIONS +OTHER)					
Orthopeadic Surgery					
Other	1	1	1		
TOTAL CASES	70	41	55	123	22

Table 14. Total cases of Smile Train Italia in all selected missions by us.

SURGERY INTERVENTIONS Chirurgo e Bambino Onlus	Mauritanian	Mauritanian	Tanzanian	Tanzanian	Tanzanian
	2007	2009	2015	2015	2016
CONGENITAL					
Unilateral Lip Repair			3		1
Bilateral Lip Repair					
Lip Scar Revision					
Lip palate cleft Repair	1				
Palate Rapair					
Palatal Fistula Closure(Revision)					
Alveolar Surgery					
Frenulum Lysis			2	2	
Nasal Deformity Correction					
Circumcision		2	24	35	47
Hypospadias Surgery			1	6	5
Orchidopexy	1	2	4	2	1
Anorectal Malformation			1		
Rectovestibular Fistulae				1	
Minor Lips Synechiae				1	1
Syndactyly Release					
Inguinal Hernia	2	4	8	6	4
Umbilical Hernia	2		3	1	
Onfalocele				1	
Visceral Surgery	1	1	5		1
Myelomeningocele					
MALIGNANCIES					
Neoplasia Excision		5	3	1	
INJURIES					
Burn Scar Release		7	3	1	3
Scar revision/Z-plastic	8				3
Skin Graft	3		3		1
Abscess Incision			2	1	1
Snake Bite					
OTHER(SURGICAL INFECTIONS +OTHER)					
Orthopeadic Surgery	3				
Other			3	4	8
TOTAL CASES	21	21	65	62	76

Table 15 A. Total cases of Chirurgo e Bambino Onlus in all selected missions by us.

SURGERY INTERVENTIONS Chirurgo e Bambino Onlus	Tanzanian	Guinea B.	Guinea B.	Guinea B.	Tanzanian	Tanzanian
	2016B	2017	2017B	2018	2019	2019
CONGENITAL						
Unilateral Lip Repair					1	
Bilateral Lip Repair						
Lip Scar Revision						
Lip palate cleft Repair		5	4	2		
Palate Rapair						
Palatal Fistula Closure(Revision)						
Alveolar Surgery						
Frenulum Lysis	1					
Nasal Deformity Correction				1		
Circumcision	40				2	1
Hypospadias Surgery	2		2		6	
Orchidopexy	1		1		1	1
Anorectal Malformation	1		2	1		
Rectovestibular Fistulae			1			
Minor Lips Synechiae	1				1	
Syndactyly Release		1		2		
Inguinal Hernia	2			1	2	1
Umbilical Hernia					1	1
Onfalocele					1	1
Visceral Surgery			1	4		
Myelomeningocele				2		
MALIGNANCIES						
Neoplasia Excision		2	1	6		1
INJURIES						
Burn Scar Release	1	2	2	7	5	
Scar revision/Z-plastic	3			1		
Skin Graft	1					
Abscess Incision	2			1		
Snake Bite				1		
OTHER(SURGICAL INFECTIONS +OTHER)						
Orthopeadic Surgery				1		
Other	8	2	1	8	1	1
TOTAL CASES	63	12	15	38	21	7

Table 15 B. Total cases of Chirurgo e Bambino Onlus in all selected missions by us.

SURGERY INTERVENTIONS FES-Fundaciò	Ethiopia	Peru	Peru	Peru	Peru
	2009	2011	2012	2013	2014
CONGENITAL					
Unilateral Lip Repair	9		2		6
Bilateral Lip Repair	2		2	7	
Lip Scar Revision			1	12	
Lip palate cleft Repair	3	10	6		
Palate Rapair				3	12
Palatal Fistula Closure(Revision)		9	3	5	6
Alveolar Surgery			6		
Frenulum Lysis			6		
Nasal Deformity Correction					
Circumcision					
Hypospadias Surgery					
Orchidopexy					
Anorectal Malformation					
Rectovestibular Fistulae					
Minor Lips Synechiae					
Syndactyly Release					
Inguinal Hernia	1				
Umbilical Hernia	1				
Onfalocele					
Visceral Surgery	2				
Myelomeningocele					
MALIGNANCIES					
Neoplasia Excision	1				
INJURIES					
Burn Scar Release	13		5		2
Scar revision/Z-plastic					
Skin Graft			1		
Abscess Incision	1		1		
Snake Bite					
OTHER(SURGICAL INFECTIONS +OTHER)					
Orthopeadic Surgery					
Other	5	7	6	8	
TOTAL CASES	38	26	39	35	26

Table 16. Total cases of FES Fundaciò in all selected missions by us.

SURGERY INTERVENTIONS Paediatric Surgery Department of Ferrara	Kenya
	2004
CONGENITAL	
Unilateral Lip Repair	1
Bilateral Lip Repair	
Lip Scar Revision	
Lip palate cleft Repair	
Palate Rapair	
Palatal Fistula Closure(Revision)	
Alveolar Surgery	
Frenulum Lysis	
Nasal Deformity Correction	
Circumcision	
Hypospadias Surgery	
Orchidopexy	
Anorectal Malformation	
Rectovestibular Fistulae	
Minor Lips Synechiae	
Syndactyly Release	
Inguinal Hernia	1
Umbilical Hernia	3
Onfalocele	
Visceral Surgery	
Myelomeningocele	1
MALIGNANCIES	
Neoplasia Excision	5
INJURIES	
Burn Scar Release	20
Scar revision/Z-plastic	2
Skin Graft	3
Abscess Incision	4
Snake Bite	4
OTHER(SURGICAL INFECTIONS +OTHER)	
Orthopeadic Surgery	6
Necrotizing fascitis	5
Other	13
TOTAL CASES	68

Table 17. Total cases of Paediatric Surgery Department of Ferrara in selected mission by us.

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