The Application of Clinical Genetics

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ORIGINAL RESEARCH

Congenital malformations in Ecuadorian children: urgent need to create a National Registry of Birth Defects

This article was published in the following Dove Press journal:
The Application of Clinical Genetics
13 April 2010
Number of times this article has been viewed

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Aim: This study sets out (a) to estimate the prevalence of admissions by birth defects, using the official database of hospitals of Ecuador; and (b) to set the basis for a new National Register of Birth Defects in Ecuador that works as a program for the clinical and epidemiological investigation of risk factors in the etiology of congenital anomalies in Ecuadorian hospitals, using a case-control methodological approach. This is the first report in their class.

Methods: The data used in this study are derived from the National Register of Hospital Admission/Discharges of the Instituto Nacional de Estadísticas y Censos; data of the Ministry of Public Health were also used. Ecuador does not have an official Medical Birth Registry or a Congenital Malformations Registry.

Results: A total of 51,375 discharges by congenital malformations were registered in a 7-year period. Of these, 16,679 admissions were of children aged less than 1 year of age, with a birth prevalence rate (BPR) of 72.33/10,000 births. 77% of the congenital defects registered comprise the 50 most common birth defects observed in this age group. Cleft lip was the most prevalent birth defect in children less than 1 year of age and the second most common defect in children 1 to 5 years of age. Unilateral cleft lip shows a BPR of 4.57/10,000 births; cardiac birth defects as a group have a BPR of 4.2; hydrocephalus a BPR of 3.77; and Down's syndrome a BPR of 3.70. Undescended testicle was the most prevalent birth defect in children between 1 to 5 years. 9384 children under 1 year of age were male (55.9%) and 7053 were female (42.1%). BPR in males was 40.45 and in females 30.40.

Conclusion: This report documents the prevalence estimates for birth defects reported in the hospital discharge data. These estimates are important to 1) plan for health-care and education needs of the Ecuadorian population, 2) identify increased occurrences of birth defects in specific geographic regions, 3) serve as a reference point for assessment of provincial surveillance systems, 4) evaluate national public health interventions, 5) compare Ecuador prevalence estimates with those of other countries, and 6) help determine the appropriate allocation of resources for basic and public health research. There is an urgent need to establish a National Registry of Birth Defects involving different sources of information such as prenatal medical records, birth records and medical records during the first year of life at an early stage, and surveys on cytogenetic prenatal diagnostic surveys and cytogenetics of therapeutic abortions.

Keywords: Ecuador, genetics, birth defects surveillance, database, prevalence, epidemiology, congenital malformations

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Introduction

This study sets out (a) to estimate the prevalence of admissions by birth defects, using the database of hospitals of Ecuador; and (b) to set the basis for a new National Register of Birth Defects in Ecuador that works as a program for the clinical and

epidemiological investigation of risk factors in the etiology of congenital anomalies in Ecuadorian hospitals, using a case-control methodological approach. This is the first report in their class.

There is a lack of information on population-based studies of malformations in Ecuador;[1] the surveillance of the effects of prenatal screening and diagnosis on the birth prevalence of malformations is limited by gaps and wide variations in surveillance systems.[2] This justifies the use of official databases in the production of the information only as an initial step in the development of an organized and generalized system that gathers in an organized way birth defects data, as proposed in this paper.

The only official existing data are limited to a few hospitals, such as those that are part of the ECLAMC network (Latin American Collaborative Study on Congenital Malformations).[3] This network was established in 1973, originally with 12 maternity hospitals in 6 provinces around the country, covering approximately 4.16% of the total number of live births in Ecuador. This network reported 1.7% of newborns (1,114/66,843) and 1.3% of stillbirths (891/66,843) with some type of congenital malformation, in a study made between June 2001 and June 2005.[4] The hospitals associated with this network are mostly secondary care hospitals located in the cities of Quito, Manta, Chone, Bahía de Caráquez, Portoviejo, Cañar, Azogues, Ibarra, Loja and Machala.[5] Despite the importance of this network, this study did not cover the whole country because participation is still voluntary, which limits coverage to less of 5% of all live births in Ecuador. However, morbidity studies of children indicated that genetic diseases and congenital malformations represent 10% to 25% of hospitalizations in tertiary care facilities, especially in some Latin America cities.[6,7]

Ecuador has a relatively small but genetically highly diverse population across the whole country. There is a need for a central coordination of information on availability of prenatal diagnosis, newborn screening, and genetic testing with modern genetic technologies. It should be stressed that demographic factors also have a great influence on the prevalence of some congenital malformations.[8] In this regard, it should be noted that Ecuador is located in western South America,[9] where half the population lives in cities with altitudes of 2000 m asl.[10] The population is 14 million, approximately half (54%) of whom live in urban zones, especially in the four largest cities of Quito, Guayaquil, Cuenca and Santo Domingo.[11] Ecuador is a multi-ethnic country with a strong Native Amerindian culture[12] that coexists with Mestizo and Afroamerican ethnic groups.

Childbearing-age women in Ecuador are potentially exposed to high teratogenic risks such as infectious agents, environmental chemical compounds, radiation, drugs, and maternal metabolic diseases.[13] These risk factors interact with the low levels of school education and low socioeconomic status of the population, and scarce resources in the public health care system for the prevention and treatment of congenital anomalies.[14] The birth prevalence of congenital anomalies in developing countries is underestimated, mainly due to deficiencies in diagnostic capabilities and lack of reliability of medical records and health statistics.[8] The recorded rates in developing countries must be considered minimum estimates because of low diagnostic capacities and underreporting.[8]

According to the health authorities of the United States,[15] birth defects are a significant public health concern, affecting ~3% of all births, and resulting in many elective pregnancy terminations or spontaneous abortions, a situation similar to that seen in Europe, where birth defects affect ~2% of all births.[16] Every year, ~150,000 babies are born with birth defects in developed countries.[17] Birth defects and genetic diseases are the leading causes of infant deaths, resulting in substantial mortality and morbidity throughout childhood.[18] Although birth defects account for only 15% to 30% of all pediatric hospitalizations in developed countries, they have a proportionally higher cost in health care programs than other hospitalizations.[19] In the US, US$8 billion are spent each year to provide medical and rehabilitative care for affected children. Thus, birth defects impart a significant burden to families and society.[20]

The causes of around 40% to 50% of birth defects are unknown,[21] 20% are attributed to a combination of hereditary and environmental factors, 8% to 10% to single-gene mutations, 6% to chromosome abnormalities, and 5% to maternal illnesses.[21] There is also an important increase in birth defects and developmental disabilities due to maternal conditions.[22] These maternal conditions comprise pre-gestational diabetes and phenylketonuria, and other related pathologies. Maternal diabetes mellitus is associated with increased teratogenesis, which can occur in pre-gestational diabetes type 1 and type 2. Cardiac defects and neural tube defects are the most common malformations observed in fetuses of pre-gestational mothers with diabetes.[23]

Certain infections, such as rubella virus (which causes German measles and congenital rubella syndrome) and cytomegalovirus (which causes a congenital infection that also produces birth defects and developmental disabilities), have shown to be highly teratogenic.[24] Equally, some medications as valproic acid and isotretionin have shown

teratogenic effects. The most teratogenic anti-epileptic drug seems to be valproic acid which causes about 2% of neural tube diseases and an additional increase of 4% to 8% in major congenital anomalies.[25] In this description, lifestyle factors such as alcohol consumption and smoking are also considered as teratogenic. Alcohol causes fetal alcohol syndrome and other spectrum disorders, for which strong prevention strategies have been developed.[26] All of the above-mentioned causes are preventable risk factors.[27]

Material and methods

Design

This is an observational descriptive study that evaluates the epidemiological issues of birth defects reported in Ecuador between the years of 2001 and 2007.

Source of information

The data used in this study were taken from the National Register of Hospital Admission/Discharges of the *Instituto Nacional de Estadísticas y Censos* (INEC),[17] and the Ministry of Public Health (MSP).[28] The Register of Admissions/Discharges is national and funded by the government. The information from the register is provided primarily by the centers and hospitals belonging to the MSP which has a national coverage and includes public maternity clinics, children's hospitals, and general adult hospitals. The information in this register was gathered from the individual clinic history, by a clerk who codes the diagnosis. This register has been, formerly and extensively, used in epidemiological studies.[8] Ecuador does not have an official Medical Birth Registry or a Congenital Malformations Registry.

Study variables

Major congenital malformation was defined as a defect detected at birth, delivery or during the first year of life, which results in death (including still birth); it requires major surgery, or has a major effect on the quality of life for the child. In this study, we used the International Classification of Diseases, 10th Edition of 1997 (ICD-10) to classify the Congenital Malformations, Deformations, and Chromosomal Abnormalities, all included in the Q00 to Q99 codes.[29] The data of two main groups of children, under the age of 1 year, and 1 to 5 years of age, were analyzed. All remaining age groups were excluded because it could not be identified if the patient was to be admitted by walk-ins or subsequent appointment. As an additional measure, duplicate records were excluded from the database and whether each patient was registered only once was reviewed, for the readmissions registry.

Statistical analysis

We analyzed birth prevalence rate (BPR) by 10,000 births. We also used data on admissions/discharges of children under 1 year of age who were admitted by birth defects or other previously acquired related complications.

Results

A total of 51,375 discharges by congenital malformations were registered in Ecuador, during the 7-year period analyzed, for all age groups. Out of the total, 16,679 admissions were of children less than 1 year of age, and with a BPR of 72.33/10,000 births. Seventy-seven percent of these comprised the 50 most common birth defects observed in this age group (see Table 1). The most common birth defect found is the unilateral cleft lip with a BPR of 4.57/10,000 births, followed by congenital heart malformations with a BPR 4.2; hydrocephalus with a BPR of 3.77 and Down's syndrome with a BPR of 3.70. 9384 children under 1 year of age were male (55.9%) and 7053 were female (42.1%). The BPR of males was 40.45 and of females 30.40.

Table 1 The most common birth defects in children under 1 year of age admitted to Ecuadorian hospitals

Rank	Code	Description	2001	2002	2003	2004	2005	2006	2007	Total	%	BPR
1	Q369	Cleft lip, unilateral	208	195	137	112	143	138	126	1059	6.35	4.57
2	Q249	Congenital malformation of heart, unspecified	131	119	143	177	139	132	135	976	5.85	4.21
3	Q039	Hydrocephalus	113	0	163	130	173	135	161	875	5.25	3.77
4	Q909	Down's syndrome	109	137	127	127	122	134	102	858	5.14	3.70
5	Q250	Patent ductus arteriosus	68	95	55	69	68	95	57	507	3.04	2.19
6	Q059	Spina bifida, unspecified	88	117	64	53	66	55	54	497	2.98	2.14
7	Q359	Cleft palate, unilateral	71	64	71	54	45	67	70	442	2.65	1.91
8	Q400	Congenital hypertrophic pyloric stenosis	62	66	36	53	66	61	64	408	2.45	1.76
9	Q750	Craniosynostosis	38	34	40	78	62	61	90	403	2.42	1.74

(*Continued*)

Table 1 (*Continued*)

Rank	Code	Description	2001	2002	2003	2004	2005	2006	2007	Total	%	BPR
10	Q899	Congenital malformation, unspecified	39	24	59	113	68	70	24	397	2.38	1.71
11	Q205	Discordant atrioventricular connection	95	108	37	38	33	30	49	390	2.34	1.68
12	Q379	Unspecified cleft palate with unilateral cleft lip	39	56	51	57	71	61	31	366	2.19	1.58
13	Q423	Imperforate anus	47	58	38	37	24	41	40	285	1.71	1.23
14	Q539	Undescended testicle, unspecified	33	26	37	29	57	59	39	280	1.68	1.21
15	Q170	Microtia	6	26	32	51	40	50	71	276	1.65	1.19
16	Q439	Congenital malformation of intestine, unspecified	32	39	38	38	38	46	42	273	1.64	1.18
17	Q663	Other congenital varus deformities of feet	60	32	30	27	31	41	51	272	1.63	1.17
18	Q699	Polydactyly, unspecified	39	39	27	31	40	46	36	258	1.55	1.11
19	Q652	Congenital luxation of the hip	21	42	37	36	22	29	37	224	1.34	0.97
20	Q390	Atresia of esophagus without fistula	26	43	25	25	36	33	27	215	1.29	0.93
21	Q212	Atrioventricular septal defect	10	15	18	20	27	82	33	205	1.23	0.88
22	Q999	Chromosomal abnormality, unspecified	11	16	9	33	30	103	3	205	1.23	0.88
23	Q043	Other reduction deformities of brain	8	38	35	32	37	22	25	197	1.18	0.85
24	Q381	Ankyloglossia	20	15	21	25	19	34	53	187	1.12	0.81
25	Q793	Gastroschisis	9	14	32	29	29	43	26	182	1.09	0.78
26	Q248	Other specified congenital malformations of heart	15	33	24	13	11	65	9	170	1.02	0.73
27	Q668	Clubfoot NOS (not otherwise specified)	24	19	21	26	32	20	21	163	0.98	0.70
28	Q213	Tetralogy of Fallot	17	32	16	9	29	25	21	149	0.89	0.64
29	Q658	Other congenital deformities of hip	17	22	15	31	12	32	16	145	0.87	0.63
30	Q419	Congenital absence, atresia and stenosis of small intestine, part unspecified	13	21	29	17	25	27	12	144	0.86	0.62
31	Q211	Atrial septal defect	0	12	10	23	24	34	35	138	0.83	0.59
32	Q02	Microcephaly	6	14	22	28	16	16	36	138	0.83	0.59
33	Q660	Talipes equinovarus	10	25	19	11	18	9	36	128	0.77	0.55
34	Q019	Encephalocele	7	15	14	14	14	29	18	111	0.67	0.48
35	Q790	Congenital diaphragmatic hernia	15	10	16	13	20	13	22	109	0.65	0.47
36	Q410	Congenital absence, atresia and stenosis of duodenum	13	11	12	9	15	17	27	104	0.62	0.45
37	Q203	Transposition of great vessels	18	17	12	12	10	19	11	99	0.59	0.43
38	Q212	Atrioventricular septal defect	0	23	10	16	14	17	16	96	0.58	0.41
39	Q897	Multiple congenital malformations, not elsewhere classified	11	12	15	18	9	20	9	94	0.56	0.41
40	Q031	Atresia of foramina of Magendie and Luschka	33	21	12	15	0	7	0	88	0.53	0.38
41	Q792	Exomphalos	9	12	15	11	13	17	11	88	0.53	0.38
42	Q228	Other congenital malformations of tricuspid valve	10	13	25	10	13	11	5	87	0.52	0.38
43	Q431	Hirschsprung's disease	17	9	15	7	10	11	16	85	0.51	0.37
44	Q620	Congenital hydronephrosis	7	15		17	14	21	9	83	0.50	0.36
45	Q054	Unspecified spina bifida with hydrocephalus	15	14	13	8	13	3	15	81	0.49	0.35
46	Q000	Anencephaly	10	11	12	14	17	8	8	80	0.48	0.34
47	Q378	Unspecified cleft palate with bilateral cleft lip	7	8	19	13	7	11	7	72	0.43	0.31
48	Q224	Congenital tricuspid stenosis	16	11	10	8	13	7	6	71	0.43	0.31
49	Q223	Other congenital malformations of pulmonary valve	2	0	0	0	19	44	2	67	0.40	0.29
50	Q255	Atresia of pulmonary artery	12	13	11	8	6	8	7	65	0.39	0.28
		Subtotal	1687	1811	1729	1825	1860	2159	1821	12892	77	55.58
		Remain birth defects	460	702	511	442	624	605	543	3887	23	16.76
		Overall	2147	2513	2240	2267	2484	2764	2364	16779	100	72.33

Notes: BPR = birth prevalence rate calculated with 2,319,737 births in the 7 years analyzed; BPR by 10,000 total births.

In Ecuador, every year 7339 children are admitted with a birth defect or other previously acquired complications; 18 patients out of every 10,000 hospitalizations are admitted with a congenital defect. Cardiac defects are the main reason for hospitalization and cleft lip is the most prevalent birth defect. Microtia and anotia show the highest prevalence in Latin America, according to the ECLAMC data.[4] One percent of all deaths are from congenital malformations and 36% of these were mainly due to cardiac congenital defects.

Table 2 shows the birth defects in children 1 to 5 years of age. In this group the most common birth defect was undescended testicle with a BPR of 9.36/10,000 births, followed by unilateral cleft palate with a BPR of 5.32, patent ductus arteriosus with a BPR of 2.97 and unilateral cleft palate with a BPR of 2.72. This table reports 14,495 discharges in this particular group. Both analyzed groups comprise 60.7% (31,174 admissions) of total admissions. The overall BPR of birth defects in children under 1 year is 55.58/10,000 births and in children between 1 and 5 years is 50.33/10,000 births.

Table 3 compares prevalence rates by country and network; our prevalence rates are significantly lower than those of each country analyzed. Table 4 shows the major

Table 2 The most common birth defects in children 1 to 5 years of age that were admitted to Ecuadorian hospitals

Rank	Code	Description	2001	2002	2003	2004	2005	2006	2007	Total	%	BPR
1	Q539	Undescended testicle, unspecified	352	320	240	293	288	339	339	2171	14.98	9.36
2	Q359	Cleft palate, unilateral	188	223	173	167	141	184	159	1235	8.52	5.32
3	Q250	Patent ductus arteriosus	92	116	75	102	94	88	121	688	4.75	2.97
4	Q369	Cleft lip, unilateral	120	114	68	82	97	78	73	632	4.36	2.72
5	Q381	Ankyloglossia	46	63	64	61	62	90	121	507	3.50	2.19
6	Q652	Congenital luxation of the hip	76	50	71	84	45	52	71	449	3.10	1.94
7	Q205	Discordant atrioventricular connection	63	106	56	44	36	43	52	400	2.76	1.72
8	Q039	Congenital hydrocephalus	63	0	64	53	43	77	76	376	2.59	1.62
9	Q658	Other congenital deformities of hip	18	28	22	25	33	72	68	266	1.84	1.15
10	Q249	Congenital malformation of heart, unspecified	33	30	39	36	41	30	49	258	1.78	1.11
11	Q660	Talipes equinovarus	9	51	53	26	24	34	55	252	1.74	1.09
12	Q379	Unspecified cleft palate with unilateral cleft lip	32	35	41	32	33	49	28	250	1.72	1.08
13	Q213	Tetralogy of Fallot	30	54	42	25	17	28	52	248	1.71	1.07
14	Q549	Hypospadias	38	50	24	32	22	39	40	245	1.69	1.06
15	Q699	Polydactily	41	33	27	27	40	44	28	240	1.66	1.03
16	Q663	Other congenital varus deformities of feet	26	21	31	37	35	19	35	204	1.41	0.88
17	Q892	Persistent thyroglossal duct, thyroglossal cyst	39	32	26	22	21	25	38	203	1.40	0.88
18	Q668	Deformities of feet: clubfoot, hammer toe, congenital talipes	30	36	14	30	28	36	22	196	1.35	0.84
19	Q909	Down's syndrome	21	35	26	36	28	21	27	194	1.34	0.84
20	Q750	Craniosynostosis	18	24	29	28	28	26	24	177	1.22	0.76
21	Q210	Ventricular septal defect	12	16	16	26	14	30	36	150	1.03	0.65
22	Q899	Congenital malformation, unspecified	5	0	31	67	12	24	8	147	1.01	0.63
23	Q439	Congenital malformation of intestine, unspecified	14	21	19	28	17	23	20	142	0.98	0.61
24	Q043	Other reduction deformities of brain	7	77	9	7	10	12	8	130	0.90	0.56
25	Q552	Other congenital malformations of testis and scrotum	27	15	17	13	10	19	29	130	0.90	0.56
26	Q431	Hirschsprung's disease	18	24	19	14	17	18	11	121	0.83	0.52
27	Q02	Microcephaly	14	10	14	23	15	28	17	121	0.83	0.52
28	Q709	Syndactyly	20	18	17	10	15	19	18	117	0.81	0.50
29	Q211	Atrial septal defect	7	13	12	14	9	18	39	112	0.77	0.48
30	Q532	Undescended testicle, bilateral	17	7	11	4	15	16	34	104	0.72	0.45
31	Q531	Undescended testicle, unilateral	0	0	1	1	1	10	86	99	0.68	0.43
32	Q740	Other congenital malformations of limb(s)	9	8	16	12	20	11	15	91	0.63	0.39
33	Q100	Congenital blepharoptosis	9	8	8	14	21	15	15	90	0.62	0.39
34	Q556	Other congenital malformations of penis	5	3	3	23	35	7	5	81	0.56	0.35

(*Continued*)

Table 2 (*Continued*)

Rank	Code	Description	2001	2002	2003	2004	2005	2006	2007	Total	%	BPR
35	Q423	Imperforate anus	22	13	11	3	8	12	9	78	0.54	0.34
36	Q181	Preauricular sinus and cyst	3	12	9	13	8	6	13	64	0.44	0.28
37	Q059	Spina bifida, unspecified	8	16	8	5	13	0	12	62	0.43	0.27
38	Q643	Other atresia and stenosis of urethra and bladder neck	10	23	6	5	1	5	11	61	0.42	0.26
39	Q393	Congenital stenosis and stricture of esophagus	15	7	6	5	8	10	6	57	0.39	0.25
40	Q620	Congenital hydronephrosis	3	5	5	7	8	11	16	55	0.38	0.24
41	Q204	Double inlet ventricle	12	8	6	4	6	12	6	54	0.37	0.23
42	Q430	Meckel's diverticulum	6	12	3	5	10	11	7	54	0.37	0.23
43	Q212	Atrioventricular septal defect	10	8	7	5	5	4	10	49	0.34	0.21
44	Q172	Microtia	4	1	10	8	8	4	13	48	0.33	0.21
45	Q251	Coarctation of aorta	4	8	3	3	5	9	16	48	0.33	0.21
46	Q541	Hypospadias	1	10	13	6	3	5	9	47	0.32	0.20
47	Q692	Accessory toe(s)	7	5	12	4	4	4	9	45	0.31	0.19
48	Q378	Unspecified cleft palate with bilateral cleft lip	2	4	14	8	5	3	7	43	0.30	0.19
49	Q540	Hypospadias, balanic	3	8	3	6	7	6	10	43	0.30	0.19
50	Q255	Atresia of pulmonary artery	5	6	10	1	4	8	8	42	0.29	0.18
		Subtotal	1614	1787	1504	1586	1470	1734	1981	11676	80.5	50.33
		Remain birth defects	355	328	353	339	474	463	507	2819	19.5	12.15
		Overall	1969	2115	1857	1925	1944	2197	2488	14495	100	62.49

Notes: BPR = birth prevalence rate calculated with 2'319,737 births in the 7 years analyzed.

congenital malformations reported by the ECLAMC Network, a rate calculated as 66,843 births out of 12 hospitals in this network.

Birth defects caused 1% of all deaths in Ecuador during the period analyzed. Cardiac malformations (35.95% of all cases) were the highest cause of birth defect mortality, followed by congenital malformations (10.66%). Congenital malformations of spleen, adrenal gland, parathyroid or thyroid gland, persistent thyroglossal duct and cyst, and the situs inversus comprised the other unclassified causes (Table 5).

Discussion

Birth defects

The overall prevalence at birth of the selected congenital defects in Ecuador was 72.3/10,000 births. This result is significantly lower than in the registries of other countries mainly due to under-reporting and the low quality of Ecuador's surveillance system. These figures should be taken as minimal estimates with uncertain diagnostic accuracy because Ecuador does not have an official medical birth registry or a congenital malformations registry.

However, in Ecuador the low level of education and cultural misconceptions have led many families to hide birth defects because their reporting could lead to the families being stigmatized by their social group, mainly in isolated rural populations.[30] There is limited knowledge of genetics and its terminology in the general population. Shamanic and marginal health practices seem to remain prevalent especially in rural communities due to the lower costs and the lack of access to health care, the personal attention the individuals receive, and the holistic point of view used.[31] Furthermore, there has been an increase in teenage pregnancies in recent years in Ecuador, aggravated by the major risk factors such as low family income, poor education, lack of knowledge about reproductive health and poor psychological family support. Adverse outcomes in mothers, such as high rates of cesarean section, puerperal infections, and complication during childbirth, have been identified; and adverse outcomes also in the fetus, such as premature birth, low birth weight and small size for gestational age have been identified also. All of these contribute to the numbers of birth defects.[32]

Because we found a massive under-reporting of birth defects in the Admissions/Discharge Registries, they are not a reliable single source for ascertaining congenital malformations. However, their availability allowed us to perform a natural experiment to assess our registration system and identify weaknesses in data collection. Our findings agreed with those of Penchaszadeh[13] who noted that the birth prevalence of congenital anomalies in the developing world is underestimated by deficiencies in diagnostic capabilities and

Table 3 Comparison of prevalence rates by country and network[41]

Country	Latin-America	Cuba	Costa Rica	Mexico	Spain	Finland	Texas	Ecuador	Ecuador
Network	**ECLAMC**	**RECUMAC**	**CREC**	**RYVEMCE**	**ECEMC**	**CREC**	**BDES**	**ECLAMC**	**Our data***
Year	**2005**	**2005**	**2005**	**2005**	**2005**	**2005**	**2004**	**2005**	**2009**
Total births	**192,882**	**117,923**	**71,548**	**29,463**	**106,728**	**57,927**	**383,192**	**66,843**	**2,319,737**
Anencephaly	5.08	2.46	1.26	2.72	0.19	3.11	2.24	3.1	0.34
Spina bifida	8.71	5.43	2.80	4.75	1.50	5.01	4.49	4.2	2.49
Encephalocele	2.64	1.36	0.56	1.02	0.28	2.07	0.55	0.9	0.48
Microcephaly	3.94	0.93	1.68	3.05	1.03	1.73	8.72	1.9	0.59
Holoprosencephaly	1.56	0.76	0.00	2.72	0.47	1.73	0.99	nr	0.04
Hydrocephaly	14.78	8.90	1.26	7.47	1.97	5.18	6.03	5.5	3.77
Anophthalmos	2.70	0.17	0.00	1.36	0.09	0.35	0.29	nr	nr
Microphthalmos	1.30	0.17	0.70	nr	1.41	1.21	2.30	nr	nr
Anophthalmos/ microphthalmos	0.00	0.08	0.00	nr	0.00	0.00	0.00	2.1	nr
Anotia	0.41	0.08	0.00	9.16	0.00	nr	0.31	nr	nr
Microtia	6.95	0.25	1.96	nr	1.31	nr	3.00	10.8	1.19
Unspecified anotia/microtia	0.10	0.25	0.00	nr	0.00	4.66	0.00	nr	nr
Transposition of great vessels	0.62	2.37	0.14	0.68	1.22	3.63	4.36	2.1	0.43
Tetralogy of Fallot	1.24	1.53	1.12	0.00	0.75	4.66	2.66	nr	0.64
Hypoplastic left heart syndrome	1.04	1.53	0.14	0.00	0.28	4.49	2.01	0.3	nr
Coarctation of aorta	0.31	1.10	0.28	0.00	0.75	8.11	4.38	nr	0.19
Choanal atresia, bilateral	0.21	0.00	0.28	0.00	0.09	1.04	0.73	nr	0.17
Cleft palate without cleft lip	5.86	2.37	2.38	3.05	4.12	14.33	5.09	4.2	1.91
Cleft lip with or without cleft palate	14.52	4.66	6.01	12.56	3.09	11.05	11.46	18	3.24
Esophageal atresia/stenosis with or without fistula	3.37	2.37	2.38	2.72	1.87	3.80	1.57	2.8	0.93
Small intestine atresia/stenosis	3.99	1.87	0.98	2.38	0.37	0.86	1.72	0.9	0.62
Anorectal atresia/stenosis	5.81	0.93	3.77	4.41	1.97	4.66	4.33	3.9	1.23
Undescended testis	7.05	3.48	8.39	nr	2.44	nr	10.52	nr	1.21
Hypospadias	4.15	10.18	4.89	5.77	1.31	12.08	16.26	2.5	0.18
Epispadias	0.05	0.34	0.14	0.34	0.19	2.76	0.65	nr	nr
Indeterminate sex	2.49	0.51	1.82	2.72	0.66	0.00	0.81	nr	0.08
Renal agenesis	2.64	0.85	1.12	1.02	0.19	1.55	1.91	nr	0.05
Cystic kidney	3.27	2.80	0.28	0.68	1.78	1.90	5.30	2.2	0.31
Bladder exstrophy	0.21	0.17	0.00	0.34	0.09	7.60	0.29	nr	0.03
Polydactyly, preaxial	4.25	0.85	9.50	11.20	3.19	0.69	3.00	3	1.11
Diaphragmatic hernia	3.63	2.46	2.80	1.36	1.03	0.00	2.56	1.6	0.47
Omphalocele	4.51	2.37	1.54	2.04	0.84	3.80	2.04	1.3	0.38
Gastroschisis	5.18	3.31	1.12	5.77	0.09	5.35	4.18	0.1	0.78
Prune belly sequence	0.73	0.08	0.56	0.68	0.09	0.17	0.31	nr	nr
Trisomy 13	0.67	1.19	1.12	0.00	0.47	0.35	1.17	nr	nr
Trisomy 18	1.71	1.36	1.82	0.00	0.47	1.38	2.45	nr	0.05
Down's syndrome, all ages	18.51	10.94	8.11	11.20	7.40	7.60	12.81	13.6	3.70

*Our data are from the national Registry of Admission/Discharge, source INEC.[11] It analyzed the data from children under 1 year of age.

Abbreviations: ECLAMC, Latin American Collaborative Study of Congenital Malformations; RECUMAC, Cuban Register of Congenital Malformation; RYVEMCE, Mexican Registry and Epidemiological Surveillance of External Congenital Malformations; ECEMC, Spanish Collaborative Study of Congenital Malformations; BDES, Texas Birth Defects Epidemiology and Surveillance Branch; CREC, Costa Rican Birth Defects Register Center.[41]

lack of reliability of medical records and health statistics. As a result, recorded diagnoses in statistics focus on overt acute illnesses, rather than on pre-existing congenital conditions that increase vulnerability to infections and malnutrition.

Cleft lip was the most prevalent birth defect in children under 1 year of age, and the second most common defect in children of 1 to 5 years of age. This finding seems similar to that of the Poletta[33] study, who said that for cleft lip and cleft

Table 4 Major congenital malformations in Ecuador reported by the ECLAMC Network[4]

Malformation	N =	Rate	ICD-10	ICD-8	Rank
Cleft lip	120	18	Q35	749A	1
Down's syndrome	91	13.6	Q90	7593	2
Postaxial polidactily	90	13.5	Q69	7550	3
Talipes equinovarus	73	10.9	Q66	7541	4
Microtia/anotia	72	10.8	Q17	745A	5
Subluxation of hip	72	10.8	Q65	7556	6
Hydrocephaly	37	5.5	Q03	7420	7
Bifid spine	28	4.2	Q05	741	8
Cleft palate	28	4.2	Q36	7490	9
Imperforate anus	26	3.9	Q42	7512	10
Anencephaly	21	3.1	Q00	7400	11
Septal defects	20	3.0	Q21	746SE	12
Preaxial polidactily	20	3.0	Q69	7550B	13
Esophageal atresia	19	2.8	Q39	7502	14
Syndactyly	18	2.7	Q70	7551R	15
Hypospadias	17	2.5	Q54	7522	16
Limb agenesia (amputation)	17	2.1	Q74	755/2	17
Polycystic kidney	15	2.2	Q61	7531	18
Trunk conal defect	14	2.1	Q21	746TO	19
Anophthalmos/microphthalmos	14	2.1	Q11	744	20
Talipes talovalgus	13	1.9	Q66	7542	21
Microcephaly	13	1.9	Q02	7431	22
Congenital hydronephrosis	12	1.8	Q62	7532	23
Diaphragmatic hernia	11	1.6	Q79	75681	24
Other cardiopathies	10	1.5	Q20	746	25

Notes: BPR calculated from 66,843 lives births in 12 hospitals of the network.
Abbreviations: ICD, International Classification of Diseases 10th Edition and 8th Edition.[29]

Table 5 General mortality rates by birth defects in Ecuador

Year	N =	PMR	Mortality rate
2001	580	1.050	0.045
2002	510	0.918	0.039
2003	480	0.897	0.037
2004	503	0.919	0.039
2005	555	0.977	0.042
2006	617	1.065	0.046
2007	678	1.169	0.050
Total	3923	1.001	0.043
ICD-10	**N =**		**%**
Q24: Dextrocardia, levocardia, cor triatriatum, pulmonary infundibular stenosis, congenital subaortic stenosis, malformation of coronary vessels, congenital heart block, others	919		23.43
Q89: Congenital malformations of spleen, of adrenal gland, other endocrine glands; situs inversus; conjoined twins; multiple congenital malformations	418		10.66
Q03: Congenital hydrocephalus	271		6.91
Q01: Anencephaly and similar malformations	204		5.20
Q21: Congenital malformations of cardiac septa	204		5.20
Q25: Congenital malformations of great arteries	172		4.38
Q90: Down's syndrome, trisomy 21	157		4.00
Q20: Congenital malformations of cardiac chambers and connections	115		2.93
Q79: Congenital diaphragmatic hernia, exomphalos, gastroschisis, prune belly syndrome, others	112		2.85
Q87: Multisystemic birth defects, congenital syndromes	110		2.80
Subtotal	1763		68.37
Others birth defects	2160		31.63
Overall	**3923**		**100.00**
Q20 + Q21 + Q24 + Q25 (all cardiac birth defects)	1410		35.94

Source: INEC.[11]
Abbreviation: PMR, proportionate mortality rate.

palate high birth prevalence rates clusters were associated with high altitude above sea level, Native Amerindian ancestry, and low socioeconomic status; low birth prevalence rate clusters showed an association with African and Black ancestry. Advanced maternal age is a recognized risk factor for cleft palate only. Weinberg[34] has suggested that similar occult lip defects are present in individuals affected with isolated cleft palate, and also that cleft palate and cleft lip plus cleft palate are etiologically distinct. These findings raise the possibility that some cleft palate cases may be misclassified.

Facial clefts are a heterogeneous group of easy-to-recognize, nonfatal birth defects. Worldwide, it was reported as the most common congenital facial abnormality. A small proportion occur as a part of recognizable patterns of malformations or a genetic etiology, while epidemiologic data suggest that exogenous factors contribute to these conditions. Maternal factors, which have been studied for their influence on cleft risk, include smoking, alcohol consumption, medication use, environmental chemicals and nutritional factors, but none appear to explain a significant proportion of the population burden of these anomalies. Geographic differences in birth prevalence for these anomalies probably reflect differences in maternal life style and exposure to environmental causative factors.

Undescended testicle was the most prevalent birth defect in children between 1 and 5 years of age. Cryptorchidism is a common congenital anomaly that shows familial clustering and increased prevalence in first-degree relatives,

suggesting that genetic factors contribute to the etiology. Nonsyndromic cryptorchidism is a common and complex disorder of unknown etiology with geographic and, perhaps, temporal variability. Although presumed to be multifactorial in etiology, few specific genetic or environmental factors have been clearly linked to this disease; there is evidence for multilocus genetic susceptibility.[35]

Cardiovascular system defects were by far the most common group of birth defects in our population. The prevalence rate for this kind of defect was very similar to rates previously published in comparable countries.[36] However, it was possibly underdiagnosed in some pathologies due to lack of routine diagnostic systems, and because echocardiography and karyotype analysis are unavailable in the smaller provinces. It should be stressed that small cardiac defects close spontaneously in 30% to 50% of the cases. The most common cardiac birth defect was patent ductus arteriosus or patent arterial duct (PAD), defined as persistent patency in term infants older than 3 months. Isolated PAD is found worldwide in around 1 out of 2000 full-term infants. A higher prevalence is found in preterm infants, especially those of low birth weight.[37] Persistence of the duct is associated with chromosomal aberrations, asphyxia at birth, birth at high altitude and congenital rubella. Occasional cases are associated with specific genetic defects (trisomy 21 and 18, and the Rubinstein-Taybi and CHARGE syndromes). Familial occurrence of PAD is uncommon and the usual mechanism of inheritance is considered to be polygenic, with a recurrence risk of 3%. Rare families with isolated PAD have been described in whom the inheritance appears to be dominant or recessive.[37]

Over the past few decades, there has been major progress in the understanding and management of cardiac birth defects, including identification of genetic causes for some conditions. Although early interventions have transformed the outcome for these patients, many have ongoing problems that require tertiary cardiac care in adult life. Furthermore, most adults require additional nontertiary care for issues such as pregnancy, noncardiac surgery, endocarditis and other problems. It is an important problem in public health, especially in relation to the costs of the hospitalization. These findings indicate a strong need to standardize both diagnostic and registration criteria for congenital heart malformations.

Our overall figure for Down's syndrome was 3.8/10,000 births. Other published population-based rates for this syndrome are higher, as the ECLAMC study[4] that found a BPR of 13.6/10,000 births. Down's can be diagnosed relatively easily prior to birth by measuring alphafetoprotein, human chorionic gonadotropin and unconjugated estriol in fetal serum, detecting a thickened nuchal fold on fetal ultrasound, and by cytogenetic analysis. Thus, it is likely that many fetuses with Down's were aborted electively and that variable abortion rates contribute to the variable prevalence of birth rates. In Ecuador, abortion by professional clinicians is allowed.

The prevalence of specific types of congenital anomalies at low and high altitudes in South America is higher in the high altitude lands than in the lowlands, especially for six types of birth defects: cleft lip, microtia, preauricular tag, branchial arch anomaly complex, constriction band complex, and anal atresias.[38] Other authors have shown that altitude is associated with low birth weight and intrauterine growth retardation.[39] These could be the most likely explanations[40] for the unilateral cleft lip, the most frequent birth defect in Ecuador.

Limitations and strengths of this study

This report has at least five limitations in relation with the findings. First, this report does not determine severity within each type of birth defect; it analyzed the crude data without analyzing in depth each clinical situation. This limits the utility of these data for health-care planning, and justifies broader studies on this issue.

Second, this analysis could not separate children with isolated defects from those with more than one major defect or those with a recognized syndrome because the used registries do not emphasize these defects, and training in and knowledge of genetics of the health care providers, especially in primary care, is still very limited.

Third, it was not possible to determine how much of the variation is attributable to specific risk factors, and the prevalence of some of the defects is influenced by the sources of prenatal diagnoses used; this prevalence varies across hospitals and provinces in Ecuador. In some cases, the limitations are greater and clinical experience still remains the main criterion of diagnosis. The findings in this report represent a conservative estimate of the number of cases each year across the nation, but these data are only an estimate of congenital defects, which would be higher for some defects, if the data were based on systems that included prenatal and postnatal sources.

Fourth, these national estimates represent minimum estimates for the impact of these defects, because even those surveillance systems with active case-findings do not achieve 100% ascertainment.

Finally, some of the most common birth defects could be under represented and could not be included because identification of these conditions depends on referral patterns and access to and use of diagnostic procedures which vary from one hospital to another.

The creation of a National Registry of Birth Defects

This report documents the prevalence estimates for birth defects reported in the Hospital Discharge data. These estimates are important to 1) plan for health-care and education needs of the Ecuadorian population, 2) identify increased occurrence of birth defects in specific geographic regions, 3) serve as a reference point for assessment of provincial surveillance systems, 4) evaluate national public health interventions, 5) compare Ecuador prevalence estimates with those of other countries, and 6) help determine the appropriate allocation of resources for basic and public health research.

Hospital-based estimates help quantify the public health importance of these defects and can help improve the planning of services for affected children and their families; eg, the need for specific clinical specialists or multispecialty clinics. Children affected by certain birth defects could benefit from the availability of multispecialty clinics to address the coordination of multiple needs and continuity of ongoing care in a single setting. Because not all provinces have surveillance systems, the national prevalence estimates can be used by provinces to assess health services and special education programs, as well as to evaluate and improve their existing health programs and ensure that affected children are referred to the appropriate services.

Accurate national prevalence estimates of birth defects are essential because birth defects are one of the leading causes of infant mortality and a major contributor to childhood morbidity. Continued improvement can be achieved by a) enhancing completeness of ascertainment, b) increasing the consistency of methods among birth defects surveillance systems, and c) expanding the methods of data collection and analysis of birth defects for which reliable and valid estimates of national prevalence can be made.

In general, this study was limited to selected major birth defects, even though it is the first to provide population-based data on the prevalence rates within their class. The methods used for data collection and case generation are not enough to provide all the required information. Comparison with an independent source such as the birth medical history would be necessary to complete and improve the quality of the registries. Also, it would be important to begin registering defects in elective abortions, and in private medical offices where pathological prenatal identification is routine. As life can be sustained with many malformations, particularly with modern treatment and surgical correction, they are not detected by vital registration systems. Mortality data cannot provide reliable indications of birth prevalence of live birth malformations, and thus registries of such malformations are important.

Birth defects are a true public health problem that has been underestimated by health authorities in Ecuador. The emphasis by public health professionals on solving simpler problems such as diarrhea and respiratory infections has meant the neglect of this group of diseases, and birth defects have become almost hidden diseases. This study allows us to understand the urgent need to establish a National Registry of Birth Defects, involving different sources of information such as prenatal medical records, birth records, and postnatal medical records during the first year of life at an early stage, and surveys of cytogenetic prenatal diagnostic surveys and cytogenetics of therapeutic abortions.

The demonstrated prevalence and lack of documentation are sufficient reasons to initiate this registry. Of course, this new record will have to be combined with other measures such as a genetics education program for health providers, a public campaign to encourage healthcare workers to report cases of patients with genetic defects, and a specialized genetic counseling training program.

Contribution of authors

The conception, study design analysis and interpretation of data, drafting, critical revising and final approval of this manuscript were perfomed equally by FGA and RLP. Both authors are the guarantors of the paper.

Ethical approval

Not required as the study concerned retrospective analysis of a database.

Disclosures

The authors declare no conflicts of interest. No funding was received for this work.

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