The Pharma Innovation Journal 2019; 8(6): 06-11

www.ThePharmaJournal.com

The Pharma Innovation

ISSN(E): 2277- 7695
ISSN(P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(6): 06-11

www.thepharmajournal.com
Received: 06-04-2019
Accepted: 08-05-2019

Dr. Fawzi Hashim Atshan
Al-Karkh Health Directorate, Baghdad, Iraq

Dr. Ibtesam Farage Hassan
Al-Karkh Health Directorate, Baghdad, Iraq

Dr. Sawsan Abdul Wahhab Hommadi
Al-Karkh Health Directorate, Baghdad, Iraq

Correspondence
Dr. Fawzi Hashim Atshan
Al-Karkh Health Directorate, Baghdad, Iraq

Evaluation of newborn screening program in Baghdad Al-Karkh health directorate in 2018

Dr. Fawzi Hashim Atshan, Dr. Ibtesam Farage Hassan and Dr. Sawsan Abdul Wahhab Hommadi

Abstract
Background: The neonatal screening program in Iraq is considered as a systematic public health program to screen infants in the first 3 to 5 days after delivery up to 1 month of age. A heel prick blood sample was taken from neonates and sent to general public health laboratory to screening Congenital hypothyroidism, Phenylketonuria and Galactosemia in 2018.
Aim of the study: To over view of the newborn screening program and estimate screening efficiency based on: the coverage rate, detection(diagnostic) ability, newborn bloodspot screening - timeliness of sample collection, newborn bloodspot screening - timeliness of sample receipt and number needed to screen to diagnose one case in the whole program in Baghdad Al-Karkh Health Directorate in 2018.
Patients and Methods: Retro- descriptive study conducted at Baghdad/Al-karkh Health Directorate which includes 10 districts are (Al-Karkh district. Al-Adel district. Al-Doura district. Al-Ilam district. Abo Gareb district. Al-A'amil district. Al-Mahmoodia district. Al-Tajee district. Al-Kadhemiya district, Al-Tarmia district). And two hospitals are Central child teaching hospital and AL-Yarmook teaching hospital. The number should be screened in Baghdad/ Al-Karkh from 1st of January-31st of December 2018 was (91266), or called the Annual target of newborn. (54168) of them screened at age of 3-30 days after delivery in 2018. By using the special statistical form which designed by researchers to retrieve and analyze the data through Excel software sheets 2007. The categorical variable which are summarized as numbers and percentages presented in forms of tables (descriptive statistical approaches).
Results: The coverage rate was (60%) of the number should be screened where the highest percentage of the coverage rate which achieved in Al-Adel districs was (90%) and lowest in Al-Kadhemiya districs was (39%), the number of positive screened test for all diseases included in the program were (59) cases, then the confirmed diagnosed cases were (45), while the detection ability of the program was (0.083%) and the last result was the number needed to screen and diagnose one case in the whole program was (1204) cases.

Keywords: Newborn screening program, congenital hypothyroidism (CHT), phenylketonuria (PKU)

Introduction
Genetic and metabolic disorders are the major causes of mortality before birth and during infancy. More than half of the congenital abnormalities usually remain undetected and are incidentally diagnosed later in life p [1]**.** 90% of such births occur in mid and low-income countries [2], required efficient program to early detection and treatment of such newborn with genetic or metabolic disorders soon after birth otherwise led to disability or even death [3]. In developed countries the newborn screening program is a public health activity aimed at the early identification, treatment & management of affected newborns [4]. Each year > 98% of approximately 4 million newborns in the United States are screened. Through early identification. Newborn screening provides an opportunity for treatment and significant reductions in morbidity and mortality [5, 6]. In developing countries the newborn screening program is either not yet a priority or is just emerging as a priority. In the Middle East and North Africa there is 7 million annual births and some of the highest rates of consanguinity in word [7]. In Iraq, the Ministry of Health paid particular attention to the newborn screening program as they are the basis for a society free of disease and their members are in good health, thus it establish programs needed to achieve this goal [8]. The health promotion units and media begun awareness campaigns for this program through seminars and meetings for parents and urged them to cooperate for the success of the program [9]. In Baghdad /Al-Karkh Health Directorate as far as we know the last study done for evaluation the program in Baghdad /Al-karkh by (Lujain & Abeer) in 2014 the results were the coverage rate 66%, the total positive cases which are included in the program were (59) and confirmed cases were

(24) while the detection ability of the program was (0.028%) [10]. The annual incidence of GAL is estimated to be between 1/40,000 and 1/60,000. The incidence rate varies in different populations i.e. 1 case per 40,000-60,000 persons in (USA), 1 case in 70,000 people in (UK) but 1 case in 20,000 people in (Ireland). In Asians, this disorder is less common [11]. Annual incidence of PKU is 1:10000 of birth [12]. PKU is found often in Caucasian populations worldwide, with much lower rates in people of African, Hispanic, and Asian ancestry. The Middle East has comparable rates of PKU too much of the Western world. The estimated incidence of 10 cases of PKU per 100,000 live births in Bahrain, 8/100,000 in Qatar, and 5/100,000 in the UAE. In comparison, the rate of PKU in the United States is about 4-6/100,000.In Oman the incidence was 2-4 cases of PKU per 100,000 live births. Annual incidence of CHT vary about 1 in 2000 to 3000 live births. In countries with neonatal screening about 1 in 6700 live births before the screening era [13]. So the program evaluation is an important organizational practice in a public health sector which may not be practiced consistently or sufficiently integrated into a daily management of the program [14].

Aim of the study

To over view of the newborn screening program and estimate screening efficiency based on: the coverage rate, detection(diagnostic) ability, newborn bloodspot screening-timeliness of sample collection, newborn bloodspot screening-timeliness of sample receipt and number needed to screen to diagnose one case in the whole program in Baghdad Al-Karkh Health Directorate in 2018.

Disorders screened

- **Galactosemia (GAL):** Is a rare genetic Autosomal recessive disorder. When Galactosemia infants feed breast milk, symptoms start appearing soon after birth. Galactose / Lactose free diet is pre-requisite condition for Galactosemic infants to pass normal life, though long term complications cannot be prevented because they are independent of diet., clinical signs & symptoms are aminoaciduria, Hepatomegaly, Ascites, Hypoglycemia are prominent signs of this disorder. Symptoms include Convulsions, Irritability, Lethargy, Poor feeding, Poor weight gain, jaundice, Vomiting. Septicemia (blood infection with E. coli) [15].
- **Phenylketonuria (PKU):** Is an Autosomal recessive inborn error of phenylalanine metabolism, caused by a deficiency of phenylalanine hydroxylase (PAH), the enzyme that catalyzes the hydroxylation of phenylalanine to tyrosine. If untreated, the neurotoxic effects of excess phenylalanine can lead to impaired postnatal cognitive development, seizures, tremors, or trembling and shaking, stunted growth, hyperactivity, eczema and musty odor of their breath, skin, or urine [16].
- **Congenital hypothyroidism (CHT):** Most neonates born with CHT have normal appearance and no detectable physical signs. Thyroid stimulating hormone (TSH) or thyroxine T4) or both can be used for CHT screening. Symptoms and signs include the following decreased activity, large anterior fontanels, poor feeding and poor weight gain, jaundice, hypo-tonia and hoarse cry [17].

Methodology

Design: retro- descriptive study.

Duration: February and March in 2019.

Setting: Baghdad/Al-karkh Health Directorate which includes 10 districts are (Al-Karkh district. Al-Adel district. Al-Doura district. Al-Ilam district. Abo Gareb district. Al-A'amil district. Al-Mahmoudiyah district. Al-Tajee district. Al-Kadhemiya district, Al-Tarmia district.) And two hospitals are Central Child Teaching Hospital and AL-Yarmook teaching hospital.

Data source: using secondary data was conducted in the primary health care centers and two hospitals were collected by special statistical form which design by the researchers for this study to retrieve and analyze the data through Excel software sheets 2007. The categorical variable which are summarized as numbers and percentages presented in forms of tables.

Sample size: Annual target of newborn in Baghdad Al-karkh Health Directorate is 91266) newborn included age was 3-30 days after delivery in 2018.

Screening methods

Newborn screening is a complex process that can be divided into 3 stages; [18]

1. Pre-analytical (education and specimens collection), In the PHCs and hospitals every infants aged 3-5 days (optimize age after delivery) up to 1 month are involved in the screening program during attendance the PHCs for receiving BCG vaccine. The healthcare providers will explain the screening test and its importance to babies and encourage them to participate in the program some time very rare refused. the collection of blood specimens take place and send every two days to the central public health laboratory(CPHL) [12].

2. Analytical (In the Central Public Health Laboratory) (CPHL) the possible outcomes of newborn screening either:

- Negative results.
- Positive results: this does not mean that the infant has a disease. The infant is suspected to be at high risk of having a disease.
- Confirmative result: confirmatory tests should be performed to confirm CHT by using sample filter paper in Iraq, while in case of PKU and GAL a new filter paper is used for confirmation. The confirmatory tests for PKU and GAL are performed outside the Iraq by tandem mass spectrometry [12].

3. Post-analytical (follow-up, education, management and evaluation in the screening clinic of either Central Child Teaching Hospital and AL-Imamim Kadhimin Teaching Hospital to be followed up and managed by the pediatricians [10].

Statistical analysis

There are several indicators (equations) used to measures the effectiveness of the program [10, 19, 20, 21]

$$1.\ \text{Newborn bloodspot screening coverage rate} = \frac{\text{Number screened}}{\text{Number should be screened}} \times 100$$

$$2.\ \text{Number needed to screen to Diagnose one case (NNS.)} = \frac{\text{Number screened}}{\text{Number of positive diagnostic tests.}} \times 100$$

$$3.\ \text{Percent of clients with positive Screening test} = \frac{\text{Number of positive screening test } (^{+}\text{ve ST.})}{\text{Number screened}} \times 100$$

$$4.\ \text{Percent of true positive Screening test} = \frac{\text{Number of positive diagnostic test (+ve DT.)}}{\text{Number of positive screening test (+ve ST.)}} \times 100$$

$$5.\ \text{Detection ability (DA.)} = \frac{\text{Number of positive diagnostic test (+ve DT)}}{\text{Number screened}} \times 100$$

$$6.\ \text{Newborn bloodspot screening-Timeliness of sample collection} = \frac{\text{The number of samples received during 1st week after delivery}}{\text{The total number of samples received during the month (reporting period)}} \times 100$$

$$7.\ \text{Newborn bloodspot screening-Timeliness of sample receipt} = \frac{\text{The number of samples received by CPHL Within 4 working days of sample collection}}{\text{The total number of samples received during The month (reporting period)}} \times 100$$

$$8\text{-}\ \text{Newborn bloodspot screening-Completeness of bloodspot samples} = \frac{\text{The number of refuse samples by CPHL}}{\text{The number of samples received by CPHL During the reporting period}} \times 100$$

Results

Out of a total live births (54168) babies were screened from the annual target (91266) with the mean coverage rate of screening was (60%) (52%) out of them was female and (48%) was male. Out of these, there were (59) positive cases for all diseases included in the program (suspected) represented (0.11 %) of all screened cases, after confirmatory test there were (45) confirmed cases represented ability of detection of program was (0.083%) of all screening cases for either CHT, PKU or GAL as shows in tables (1).

Table 1: Status of screening program coverage rate

No.	Districts And hospitals	Babies should screen(target)	Screened babies	coverage rate
1	Al-Karkh	8850	5617	64%
2	Al-Doura	9672	6721	69%
3	AboGareb	9792	3492	36%
4	Al-Mahmoodia	9918	4440	45%
5	Al-Adel	6480	6007	92%
6	Al-Ilam	9540	7308	77%
7	Al-A'amil	8280	6691	80%
8	Al-Tajee	6150	3900	64%
9	Al-Tarmia	3864	2556	66%
10	Al-Kadhemiya	18720	7216	39%
11	Central Child Teaching hospital	0	189	0
12	AL- yarmook hospital	0	31	0
General mean		91266	54168	60%

There are seven of ten districts had coverage rate above (60%) such as (Al-Karkh, Al-Adel, Al-Ilam, Al-A'amil Al-Doura, Al-Tarmia and Al-Tajee), the rest districts had coverage rate below (60%) are (Al-Kadhemiya, Abo Gareb, Al-

Mahmoodia). Newborn bloodspot screening–timeliness of sample collection

The researchers designed special forma to collect the data (APPENDIX -1) in order to identify specific conditions as soon after birth as possible, and before the onset of recognizable clinical symptoms. The optimum time period for the bloodspot sample to be taken is (3-5days) after delivery, in Iraq the last time is 30 day of age, table (2) shown the percentage of sample collection.

Table 2: Newborn bloodspot screening-timeliness of sample collection

Age/days	Screened cases	Coverage rate %
3-5 days	6340	7
3-7 days	16527	18
7-14 days	33760	37
30 days	54168	60

Appendix 1: Statistical form design by researcher

	Age/Days	No.
1st 7 days	3 day	
	4 day	
	5 day	
	6 day	
	7 day	
	8 day	
	9 day	
2nd 7 days	10 day	
	11 day	
	12 day	
	13 day	
	14 day	
	15 day	
	16 day	
3rd 7 days	17 day	
	18 day	
	19 day	
	20 day	
	21 day	
	22 day	
	23 day	
4th 7 days	24 day	
	25 day	
	26 day	
	27 day	
	28 day	
	29 day	
	30 day	

The coverage rate at the optimum time (3-5 days) was (7%), but in the 1st week after delivery was (25%), 2nd week was (37%).

1. Newborn bloodspot screening–timeliness of sample receipt:
   All the samples are send from PHCs to the CPHL twice weekly so there is no delay.
2. Newborn bloodspot screening–completeness of bloodspot samples.

The samples do not meet the quality criteria are rejected by CPHL and a request for a repeat sample called (unsatisfactory samples. The total rejected samples were (95 samples) which represented (0.18%) of total sample were send to CPHL or one rejected sample for each (5718), most of unsatisfactory samples from Al-Karkh was (21) and less unsatisfactory from Al-Kadhemiya district was one sample as in table (3).

Table 3: the rejected samples or unsatisfactory

Districts / hospital	No. of Unsatisfactory Samples
Al-Karkh	21
Al-Doura	14
AboGareb	13
Al-Mahmoodia	12
Al-Adel	9
Al-Ilam	8
Al-A'amil	8
Al-Tajee	5
Al-Tarmia	5
Al-Kadhemiya	1
Central Child Teaching Hospital	0
AL-Yarmmok hospital	0
Total	95

The detection (diagnosis) ability of program as following:

- {0.037 %, (20)} of all screening babies were positive for CHT, (44%) of them was diagnosed as CHT.
- {0.035%, (19)} of all screening babies were positive for PKU, (42%) of them was diagnosed as PKU.
- {0.011%, (6)} of all screening babies were positive for GAL and (14%) of them was diagnosed as GAL.
- {0.083%,(45)} of all screening babies were positive for CHT, PKU and GAL which is called the detection(diagnostic) ability of the program in general was as shown in table(4)

The screen cases needed to diagnose one case as shown in table (4) as follow

- To diagnosis one case of CHT need(2708) screen cases
- To diagnosis one case of PKU need(2851) screen cases
- To diagnosis one case of GAL need(9028) screen cases
- To diagnosis one case of all diseases included in program as a whole need(1204) screen cases

Table 4: Outcome of screening results

Diseases	ST + VE * Suspected cases	DT +VE ** Confirmed cases	% of confirmed case	Diagnosis (detection) ability of program	screen cases needed to diagnose one case
CHT	20	20	44	0.037	1:2708
PKU	28	19	42	0.035	1: 2851
GAL	11	6	14	0.011	1: 9028
Total	59	45	100	0.083	1: 1204

*ST = screening test **DT= diagnostic test

Discussion

The coverage rate: is one of the vital effectiveness indicators used to evaluate newborn screening programs, and it is important for the prediction of future public health decisions on such programs. This is especially in developing countries with large populations, undeveloped economies and unequal regional development [22]. The coverage rate was (60%) which is less than in United Arab Emirates, Alexandria, Saudi Arabia, Oman, Qatar the coverage rate were (70%), (95%),

(82.7%), (97%), (94%) respectively [23, 24, 25, 26, 27, 28] were the reasons for this low coverage rate may be deficiency or no maintenance supply the resources specially equipment's, linked the screening of neonates with BCG vaccine during visit the PHCs, fluctuation BCG supply to the PHCs. delay receiving BCG vaccine after 1 month of age, another cause is lack of awareness of families about the newborn screening, refusal of parents as they considered the test painful and unnecessary and may results in secondary complications in case of unhealthy ill infants. In other side the coverage rate of this study was higher than in Syria, Philippines and Bangladesh were (15%, 28% and 1% respectively), the reasons for that these countries are large populations, undeveloped economies, political or security unstable and unequal regional development [29]. It is essential to begin the screening process promptly, to identify specific conditions as soon after birth as possible, and before the onset of recognizable clinical symptoms. By detecting these conditions early, it is possible to treat and reduce their severity and there is evidence that clinical outcomes are improved [20]. The coverage rate of the program in Iraq during the optimum time period for the bloodspot sample to be taken is between 96–120 hours (3-5days) of age and no later than 168 hours (7) days [21] it was (18%), and even preferred to do the screening 1-2 weeks to avoided the effect of new born metabolic disease [22] it was (37%) as in table (2).

The total no. of screening test of CHT Performed was 54168, (0.037%) of those screened showed positive diagnostic test for CHT, which is much lower than those obtained by study done in Iran, Fars Province [30] were (63031 newborns) (0.20%) had a positive screening test and also lower than those obtained in Macedonia [31] were (9757 newborns) (0.18%) had a positive screening test.

- The total no. of screening test of PKU Performed was 54168, (0.034%) of those screened showed positive diagnostic test for PKU, which is higher than those obtained in study done in Fars Province (South Iran) and UAE were (0.01%) out of (76966) and (0.007%) out of (750 365) neonate respectively [31].
- The total no. of screening test of GAL performed was 54168, (0.011%) of those screened showed positive screening test for GAL, which is lower than these obtained in India were total of (10300 newborn) were (0.388%) of those screened showed positive diagnostic test for GAL [32]. In other side the diagnostic ability of program as whole in this study was (0.083%) which four time more than the same program in 2014 was (0.28%) [10].The neonates need to diagnosed one case as whole program was (1253) which is lower than these obtained in India which was 3600 [33], while number needed to screen to diagnose one case of CHT was (2708), which higher than obtained in Fars Province, turkey and Macedonia (1465, 469, 1220 respectively) [28, 30].

  The number needed to screen to diagnose one case of PKU was (2851) which is lower than those obtained in Fars Province South Iran and India (7.686, 10000 and 18300 respectively) [32, 33], number needed to screen to diagnose one case GAL was (9028) which is lower than those obtained in India (10300) [33] this may be due to good awareness about screening of neonates and avoided consanguineous marriages but more studies are required to know how much consanguineous marriages are affected.
- The total rejected samples were (95 samples) which represented (0.18 %) of total sample were send to CPHL or one rejected sample for each (5718) this lower than documented in the newborn screening Ontario (Canada) program which receives 145,000 samples per year about 2,6% of which rejected about 3700 sample rejected annually and in other side study done in Malaysia explained that the mean sample rejection rate was (0.11%) with (39)samples rejected out of (34715) samples that were screened [34].

Consequences of a rejection newborn screen sample

- Risk of delaying the identification of a screen positive baby.
- Additional stress to baby and family related to the collection of a second sample.
- Parents may refuse the second collection attempt resulting in a missed screen.
- Increased workload for the submitter in locating, retrieving and collecting the repeat sample.
- Increased workload to CPHL in processing, reporting and follow up for the unsatisfactory sample [35].

Conclusions

The CHT is the most common disorders in the studied samples, with coverage rate (60%) which low than the most surrounding and international Countries, but the diagnostic ability of program as a whole in this study was (0.083%) which four time more than the same program in Baghdad AL-Karkh in 2014 was (0.28%).

Recommendations

- More effort should be made to improve the program through building up enhanced direct communication systems, linking curative newborn screening programs to community-based primary health care centers especially in the districts with coverage rate below (60%).
- More Governmental priorities and commitment to this program to maintenances of the trained human, resources and instruments, medical milk and other medicine.
- Improvement of the monitoring and supervision system of the program through calculation of the coverage rate at each health districts.
- Future studies should focus on measuring the relationship of included disorders in the study and consanguinity.
- We hope future expansion of newborn screening program to all governorates of Iraq.

References

1. Smith LK, Budd JL, Field DJ et al. Socioeconomic inequalities in outcome of pregnancy and neonatal mortality associated with congenital anomalies: population-based study. BMJ. 2011; 343:d4306.
2. World Health Organization (WHO). Control of Genetic Diseases. http://apps.who.int/gb/archive/pdf_files/EB116/B116_3-en.pdf. Assess date: Jul 26, 2013)
3. Raffle A, Gray M. Screening. Evidence and Practice. Oxford: Oxford University Press, 2007.
4. American Academy of Pediatrics, Newborn Screening Task Force. Serving the family from birth to the medical home-Newborn screening: a blueprint for the future. Pediatrics. 2000; 106:383-427.
5. Centers for Disease Control and Prevention. Using tandem mass spectrometry for metabolic disease screening among newborns. MMWR, 2001; 50. (No. RR)

6. Centers for Disease Control and Prevention. Impact of expanded newborn screening-United States, 2006. MMWR. 2008; 5757(37):1012-1015.
7. Kinrich AM, Sanchez-Lara PA. Newborn screening and the incidences of inherited metabolic and endocrine disorders in the Arab Middle East, 2014. Available from: http://www.ashg.org/2014.
8. Qusay Al-Masoody. Ministry of Health prepare program to detect genetic disease in neonate. Baghdad: Baghdad news newspaper, 2012. Available from: http://www.baghdadnp.com/news.
9. Salman Jasim. AL-Russafa health Directorate: 8500 infants included in neonatal screening program were examined. Baghdad: Almustaqbal News, 2013. Available from: http://www.almustaqbalnews.net.
10. Alkhazrajy, Lujain A, Hassan Abeer Adnan. Overview of neonatal screening program applied at primary health care centers in Baghdad /Iraq.
11. Miriam Murphy, Brian McHugh, Orna Tighe, Philip Mayne, Charles O'Neill, Eileen Naughten *et al*. Genetic basis of transferase-deficient galactosaemia in Ireland and the population history of the Irish travelers. European journal of Human Genetics, 1999.
12. National Guideline of Newborn Screening for Care Providers in primary health care centers in Iraq This guideline has been developed in Iraq in close collaboration with the Ministry of Health (MOH) in, 2014.
13. Diseases cover by neonatal screening, www.cags.org.ae/gme3nbsenpku.pdf
14. Grosse SD, Van Vliet G. Prevention of intellectual disability through screening for congenital hypothyroidism: how much and at what level? Arch Dis Child, 2011.
15. Berry GT, Segal S, Gitzelmann R. Disorders of Galactose Metabolism. In: Fernandes J, Saudubray JM, van den Berghe G, Walter JH, eds. Inborn Metabolic Diseases: Diagnosis and Treatment. 4th ed. New York, NY, 2006; 7.
16. The Prevalence of Phenylketonuria in Arab Countries, Turkey, and Iran: A Systematic Review Ashraf El-Metwally.
17. Grosse SD, Van Vliet G. Prevention of intellectual disability through screening for congenital hypothyroidism: how much and at what level? Arch Dis Child, 2011.
18. Malaysian Journal of Pediatrics and Child Health Online Early MJPCH.09-20-2014.
19. Healthcare Improvement Scotland, pregnancy and newborn screening indicators, 2013.
20. NHS National Services Scotland. Pregnancy and newborn screening programmes quality indicators, 2011, Available from: http://www.pnsd.scot.nhs.uk.
21. NHS Quality Improvement Scotland. Clinical standards: pregnancy and newborn, 2005. Available from: http://www.healthcareimprovementscotland.org.
22. Screening of newborns for congenital hypothyroidism: guidance for developing programs. Vienna: International Atomic Energy Agency, 2005.
23. Al-Hosani H, Salah M, Osman HM, Farag HM, El-Assiouty HML, Saade D *et al*. expanding the comprehensive national neonatal screening programme in the United Arab Emirates from 1995 to 2011. Eastern Mediterranean Health Journal. 2014; 20(1):17-23.
24. Nihad I, Dabbous Hanan M, Abde El-Aziz, Nagwa Y, Abou El-Enein, Hisham H *et al*. Indicators of the Screening Program for Congenital Hypothyroidism in Alexandria. J Egypt Public Health Assoc. 2008; 83(3-4):308-327.
25. Al-Maghamsi MS, Al-Hawsawi ZM, Ghulam GN, Okasha AM. Screening for congenital hypothyroidism in North-West region of Saudi Arabia. Saudi Med J. 2002; 23:1518-21.
26. Pollitt RJ, Green A, Mc Cabe CJ. Neonatal screening for inborn errors of metabolism: cost, yield and outcome review. Health Technology Assessment. 1997; 1(7). Available from: www.ncchta.org.
27. Newborn screening overview. www.Genesrus.uthscsa. Edu, 2006 October.
28. Zohreh Karamizadeh MD, Hedyeh Saneifard MD, Golmhossein Amirhakimi MD, Hamdollah Karamifar MD, Mehrsadat Alavi MD. Evaluation of Congenital Hypothyroidism in Fars Province, Iran. Iranian Journal of Pediatrics. 2012; 22(1):107-112.
29. Pollitt RJ, Green A, Mc Cabe CJ. Neonatal screening for inborn errors of metabolism.
30. Anastasovska V, Koviloska R, Kocova M. High incidence of congenital hypothyroidism in one region of the republic of Macedonia. BJMG. 2014; 17(1):31-36. DOI: 10.2478/bjmg-20140024
31. Hamdollah Karamifar MD, Mahtab Ordoei MD, Zohreh Karamizadeh MD, Gholam Hossein Amirhakimi MD. Incidence of Neonatal Hyper phenylalaninemia in Fars Province, South Iran. Iranian Journal of Pediatrics. 2010; 20(2):216-220.
32. Radha Rama Devi A, Naushad SM. Newborn Screening in India. Indian Journal of pediatrics. 2004; 71:157-160.
33. Dilek Dilli, Sema Özbaş, Deniz Acıcan, Nergiz Yamak, Mustafa Ertek, Uğur Dilmen. Establishment and Development of a National Newborn Screening Program for Congenital Hypothyroidism in Turkey. J Clin Res Pediatr Endocrinol. 2013; 5(2):73-79. DOI: 10.4274/Jcrpe.929.
34. Audit of congenital hypothyroidism newborn screening in Sarawak general hospital. Wong Ann Cheng, Betty Ho Lee Sue, Chan Lee Gaik.
35. Mc Roberts, Christine. What Makes a Satisfactory Newborn Screen Sample? 2013. Newborn Screening Ontario.