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Incidence of Sepsis in Children Under 5 Years Old Within Kirkuk Province

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ABSTRACT

Objectives: *Medical researches on septicemia, particularly, in most susceptible age group of children i.e. newborns and young infants in Iraq are scanty. The aim of this study is to assess the incidence of blood poisoning via hematological parameters in children under 5 years old within Kirkuk Province.* ***Methodology:*** *Only 120 children aged 1-60 months admitted to hospital on suspicion of blood poisoning were selected and compared with other 40 healthy children of similar ages used as control.* ***Results:*** *Almost 42.5% of suspected cases admitted to hospital were diagnosed sepsis positive. Over 80% of affected sepsis cases were in children aged 1-18 months old but dropped down as the age advanced. The main blood parameters i.e. leucocytes (WBC), erythrocytes (RBC), hemoglobin (Hb%), Lymphocytes (L), Blood platelets (PLT) were significantly (p≤0.05-0.0001) affected up and down in sepsis patients in comparison with counterpart children.* ***Novelty:*** *It is concluded that the newborn and infants are more susceptible to infection than older ages due to the immaturity of the immune system in these babies, artificial rather than breast feeding, negligence and inexperience of mothers and deficiency of hygienic parameters applied. Early and regular health checkup of newborn babies under 5 years old by pediatricians deems mandatory to promote health measurements and reduce children mortality.*

INTRODUCTION

Sepsis, a life-threatening health condition triggers when the body's immune system has an extreme response in causing damage to its own tissues and organs that lead to shock, multiple organ failure and leading to mortality, if not recognized early and treated promptly [1]. Sepsis, can affect anyone, particularly, newborn, infants, young children, older people, pregnant or those with other health problems may become at higher risk; with symptoms include fever, fast heart rate, rapid breathing, confusion and body pain. Causes could usually be by bacteria entering the blood circulation (bacteremia), grow and disrupt the body's equilibrium, represents the second most common cause of illness and death in children under 5 years old as infectious diseases with a consequent inflammatory reaction [2]. More precisely, blood poisoning indicates infectious bacteria poison the blood by itself or by their toxins and any positive blood culture with systemic bacterial infection is considered as septicemia. Hospitalization and mortality are common in children affected by septic shock around the world. Official reports of World Health Organization (WHO) refer to about 85% of deaths in newborn results from infections, including tetanus, pneumonia, and sepsis. Sepsis itself represents the main cause of death for children worldwide and is linked to high rates of morbidity and mortality [3]. Death toll reaches 40% of the affected infants, mostly in developing countries; however, in underdeveloped nations, with inadequate medical infrastructure is much higher. In 2019,

almost a total of 729,000 children worldwide lost their lives to infectious diseases, with poorer nations bearing the highest rates [4]. Globally, every year about 3 million newborns and 1.2 million children have an infection a dangerous medical condition, septicemia caused due to impact of harmful bacteria in the blood [5]. The resistant pathogens count to be a cause of sepsis leading death in 30% of neonatal [6]. Although it is a major cause of global morbidity and mortality, sepsis still lacks targeted therapy. Every year more than 75,000 infant and children in USA develop severe sepsis where almost 7,000 (9.3%) die, where this toll is more than deaths from cancer in children [7]. The resultant of the uncontrolled systemic inflammation in response to an infection causes sepsis can be lethal if left untreated and can lead to tissue damage, organ failure, or dysfunction [2]. Other causes like blood invasion from pneumonia, meningitis, urinary tract infections (UTIs), an infected wound, an intestinal infection, or a skin infection can result in septicemia too [8]. In neonates, septicemia can also result from infected umbilical cords [4]. Despite available therapies, septicemia continues to be a leading cause of death for children, particularly in underdeveloped countries [3]. The immune system of children is immature and still developing, makes them more susceptible to septicemia and more vulnerable than older children. The risk is further increased by immunosuppression, hospitalization, infections, and pre-existing conditions [7];[9]. Due to the increase in instability of the country for some time number- the consequent lack of medical facilities and staff, health care services remain insufficient around countryside have all weakened Iraq's infectious disease management system. Compared to other Iraqi provinces, Kirkuk has a notably higher incidence of acute respiratory infections and lower immunization rates [10]. Early detection deems essential for lowering the death toll of septicemia. The gold standard for a conclusive diagnosis of septicemia is blood culture; however, a blood count can be used as a preliminary test to confirm the diagnosis [11]. Despite recent legislative initiatives to enhance children's health and educational chances infectious illness mortality remains high in Kirkuk, Iraq.

Both infants and young children, with septicemia, are at significant risk of dying, with symptoms in children >5 years are many i.e. the skin looks bluish, mottled or pale around the lips and eyes i.e. children feel very sleepy, difficult to rouse or wake, breathing very fast, feeling cold, with a rash that doesn't fade and suffer convulsion. Many children, particularly those under five with fever may end up with potentially fatal sepsis. Since 2003, Kirkuk province, a multiethnic area in northern Iraq, has been unsettled due to terror, extremism, and bloodshed. Women and children, the most vulnerable individuals would suffer greatly in such settings; also provide a significant danger of infection [9]. Moreover, the province of Kirkuk is a high-risk region for infectious diseases affecting children due to the devastation caused by the invasion between 2014 and 2017 and the resulting public challenges. Health care services are impacted by the complex political and social environment created by Kirkuk province's ethnic heterogeneity; therefore, investigation incidences of septicemia in children younger than five deems crucial. Septicemia, is linked to risk of some factors i.e. age, gender, nutritional condition, medical history, and test results [8]. Unfortunately, there aren't enough medical facilities in

Kirkuk to handle and treat the growing number of illnesses. Accordingly, investigations are conducted on hematology analysis of children >5, who have septicemia has been carried out to correlate the septicemia germs and certain blood parameters. The objective of this research is to correlate the incidence of septicemia caused by pathogenic bacteria to alterations in blood parameters in septicemia of children under five in the province of Kirkuk.

RESEARCH METHOD

The present work was carried out in Kirkuk city from July 7th 2024 to end of January 2025. The number of children understudy was 120 whose ages ranged between 1month-<5 years old admitted into "Gynecology and Children Hospital". An interview was carried out with these children using questionnaire form designed to collect personal data i.e. age, residency, duration, sign and symptoms of disease. Other 40 healthy children aged <5 years old were also used as healthy or control group. Peripheral blood samples of 2.5 mL from the brachial vein of the left arms were collected after sterling the skin with socked 70% ethanol (isopropyl alcohol) using sterile syringe by well trained professional nurses for blood analysis using tube containing anticoagulant EDTA followed by covering the skin spot with adhesive bandages tape to protects the vein puncture site after collection for CBC analysis [10]. An Automatic hematology analyzer DxH 900 cell counting device was used to obtain the readings of the CBC parameters. Data are collected, analyzed and plotted as appropriate. The clinical investigation had included two main different lines: (1). General checkup to diagnose the septicemia children e.g. symptoms; (2). Complete blood counting (CBC) for both genders.

RESULTS AND DISCUSSION

Results

Only 51 out of 120 children within this range of age were found septicemia positive, making almost 42.5% cases dealt with. The proportion of diagnosed male sepsis children admitted to hospital made 40% and 60% female (2/3 respectively, of the total children). Following regular clinical checkup and appropriate tests at the hospital, the remaining of 69 were considered as septicemia negative or uninfected children (57.5%). The age groups were divided into five categories: (1-12 months) with almost 53% sepsis, followed by children ages ranged between (13-24 months) with a proportion of (27%) i.e. dropped to almost 50% of those ages under 1 year 27%; and further dropped by age advanced to i.e. (25-36 months); (37-48 months); and (49-60 months) old children (Table-1 and Fig. 1).

Table 1. Distribution of age categories/months in sepsis children compared to their counterparts of negative diagnosed children.

Age (months)	Sepsis children (%)	Non-infected Children (%)	Total
1-12	27(52.9%)	33(47.8%)	60

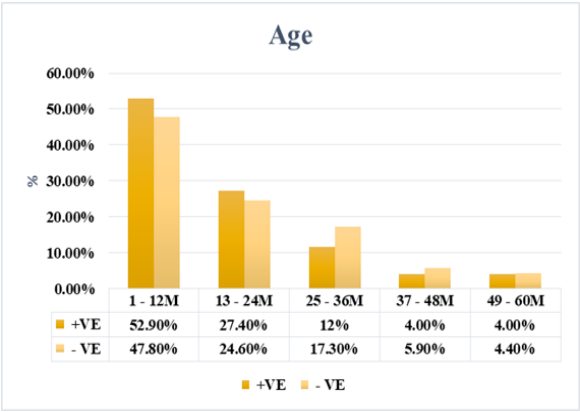
13-24	14(27.4%)	17(24.6%)	31
25-36	6(11.7%)	12(17.3%)	18
37-48	2(4.0%)	4(5.9%)	6
49-60	2(4.0%)	3(4.4%)	5
Total	51(100%)	69(100%)	120

When these positive septicemia children were compared with their counterpart negative children with the parallel ages, the differences appeared insignificant [p≤0.597]. The bio-statistical differences between the two genders was insignificant (p≤0.619) [table-2] and [Fig.2].

(Table-2): Proportion of infection of sepsis in between genders. Bio-statistical analyses included 2 sample student T-tests i.e. ANOVA and Chi-square tests to compare the differences between the categories according to infection status, gender. The difference between the genders was insignificant (p≤0.619).

Table 2. Proportion of infection of sepsis in between genders.

Gender	+ve (%)	-ve (%)	Total
Male	19 (37.3)	30(43.5)	48
Female	32 (62.7)	39(56.5)	72
Total	51 (100)	69(100)	120



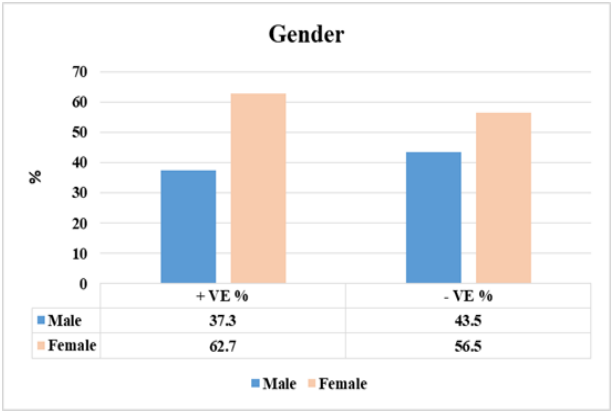


Figure 1 and 2. Distribution of age (1); and gender (2) categories/months in sepsis children compared with their counterparts of negative diagnosed children, respectively. An insignificant correlation between age and infection prevalence (p=0.597), suggests that the risk of infection in this group is irrelevant to age-dependent.

The most important blood parameters were investigated i.e. WBC, Granulocytes, Lymphocytes, RBC, HB%, MCV and PLT that have considerable roles in diagnosing many health disorders (Table-3). The WBC in the sepsis children had significantly elevated from ($8.35x10^6$±1.45)/mL to ($16.6x10^6$±12.5)/mL (Fig. 3a); similar increase in

granulocyte too (Fig. 3b); so as the lymphocyte from ($3.121x10^6$)/mL to ($6.68x10^6$)/mL (Fig. 3c).

The erythrocytes (RBC) counts had significantly dropped down from ($4.511x10^6$)/mL to ($4.198x10^6$) (Fig. 3d). Hemoglobin percentages had insignificantly dropped down from 12.583 mg/mL to 12.31 mg/mL (Fig 3e). The mean cell volume parameter in the patients had significantly risen from ($81.13x10^6$)/mL to ($86.3x10^6$)/mL. The number of platelets (PLT) too had significantly risen from ($275x10^3$)/mL to ($320x10^3$)/mL. No differential counting of WBC was performed via blood smear to confirm the proportion of formed cells frequency in blood smears except lymphocytes (Fig. 3c).

Table 3. Comparison of hematological parameters between sepsis children and control group using bio-statistical analysis (ANOVA). (**). p≤0.0003; (*) and p≤0.004-0.002.

	WBCx10^6 ±SD	Lymp-x10^6 ±SD	RBCx10^6 ±SD	HBG% g/mL	MCV	PLT
Patients (n=120)	**16.6±12.5	**6.68±6.0	*4.198±0.70	12.31±2.86	**86.3±11.6	*320±31
Control (n=40)	8.35±1.45	3.121±0.96	4.511±0.47	12.583±0.70	81.13±4.53	275±38
***p*≤**	0.0003	0.0003	0.002	NS	0.002	0.004

As an example to such a significant increase (p≤0.0002) is the lymphocyte population (L) which increased form (3.121x109)/mL in control to (6.683x109)/mL in sepsis patients (Fig. 3c) indicating infection of blood by bacteria in septicemia children, respectively.

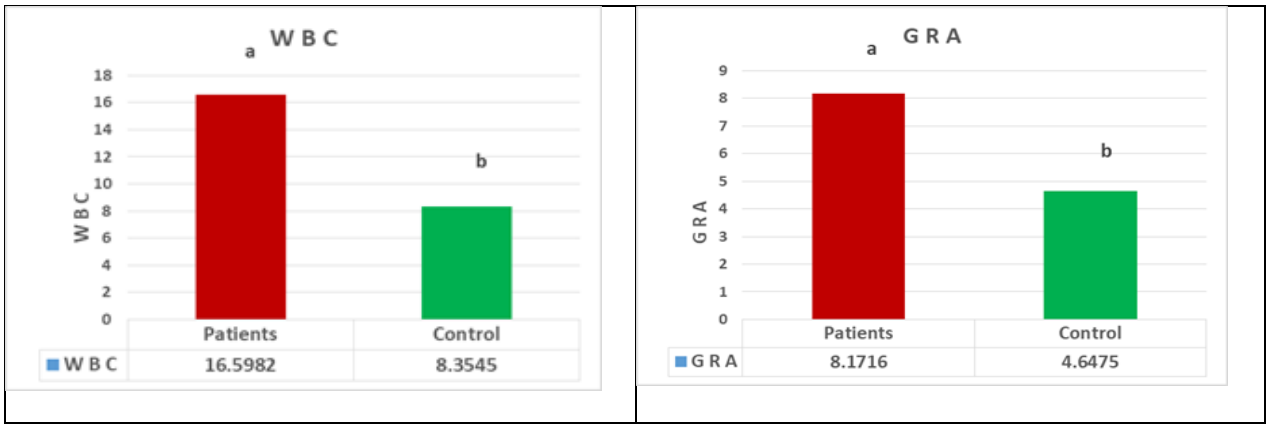


Figure 3a. Histograms demonstrate the significant changes in number both WBC; and (F3b) (p≤0.0003) in granulocyte population septicemia children, respectively in comparison with the healthy control children.

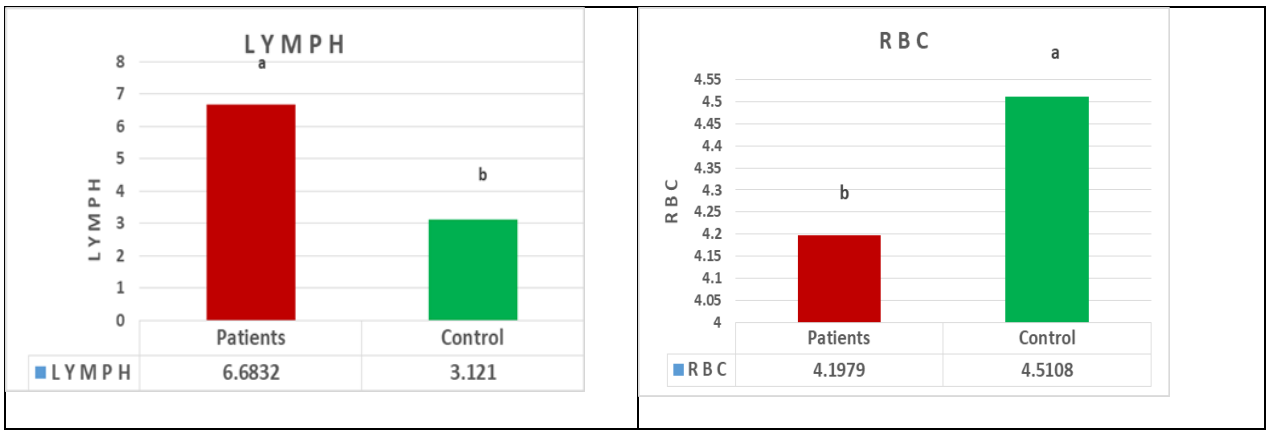


Figure 3c. A significant increase in granulocytes; and PLT (Fig. 3d), respectively is noted between the healthy control children and septicemia patients.

Erythrocytes [Red Blood Cells (RBC)] and Hemoglobin (Hb%):

The RBC levels were significantly (p≤0.002) decreased in septicemia children indicating a possible connection between infection and anemia [Fig. 3d]. However, Hb% levels had insignificantly (p≤0.358) dropped (Fig.3d & 3e).

Blood Platelets: The number of platelets (PLT) had significantly increased (p≤0.002) from 275x103±38/mL to 320x103±31/mL yet the number is within the range; nevertheless, it still alarms the impact of the bacteria on its population that may induce a possible risk of blood clouting in the children) (Fig. 3f).

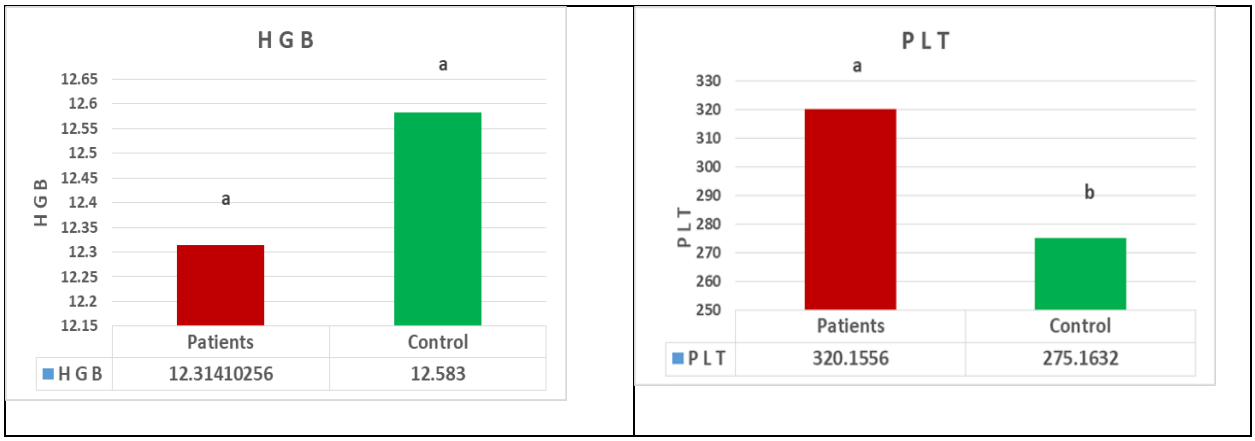


Figure 3d and 3e. Significant drop in RBC levels and insignificant drop of Hb% in septicemia children compared to healthy control children. (Fig. 3e): A significant increase in number of platelets (PLT) (p≤0.002).

Table 4. Arithmetic means ±SD and proportion of blood parameters in sepsis children in different ages compared with their counterpart of negative infection. (n): number of cases; (p): Probability test.

Ages/Months/ *p*-values	WBC±SD x10⁹	Gran±SD x10⁹	Lymph±SD x10⁹	RBC±SD x10⁹	HB%±SD g/mL	PLT±SD x10³
(1-12)						
Sepsis	15.2±2.1	8.2±1.1	7.0±1.2	4.1±0.3	10.5±1.0	300±20
Negative control	14.5±1.8	6.5±1.0	6.8±1.1	4.05±0.2	11.0±1.1	310±25

p≤value	<0.001	<0.05	<0.05	NS	<0.023	NS
(13-24)						
Sepsis (n=)	12.5±1.5	7.9±1.4	6.5±1.0	4.12±0.2	11.0±1.2	250±30
Negative control	13.0±1.7	6.2±1.0	6.7±1.2	4.1±0.3	11.5±1.0	260±28
p≤value	0.003		<0.126	0.105	<0.028	NS
(25-36)						
Sepsis (n=)	14.0±1.9	7.5±1.2	6.7±1.2	4.15±0.3	11.8±1.1	320±35
Negative control	14.5±1.6	7.7±1.1	8.0±1.3	4.12±0.2	11.2±1.0	330±30
p≤value	0.05		<0.20	<0.042	<0.035	NS
(37-48)						
Sepsis (n=)	16.0±2.0	9.0±1.3	9.0±1.4	4.18±0.3	10.2±1.0	280±25
Negative control	15.5±1.9	8.9±1.2	8.8±1.3	4.15±0.2	10.5±1.1	290±28
p≤value	0.015		<0.95	<0.018	<0.018	NS
(49-60)						
Sepsis (n=)	13.5±1.7	7.0±1.2	7.5±1.0	4.2±0.3	11.2±1.2	290±30
Negative control	13.8±1.8	7.2±1.0	7.7±1.0	4.18±0.2	11.5±1.0	300±3.0
p≤value	0.12		<0.18	<0.035	<0.042	

Discussion

Incidence of sepsis is very common disease in the Iraqi society that has a significant impact on children mortality specifically due to ignorance or unawareness of the parents of the importance of attention requested to be paid to health status of their babies postnatally. The majority (53%) of septicemia victims was amongst children aged 1-12 months old that was significantly higher than older ages and had gradually dropped by age advances. Such an early infection by bacteria may indicate extra susceptibility (prone) of younger babies to the bacterial infection than in older ones due to several reasons i.e. immature or less immune system development at such early ages in comparison with somehow older ages when more competent T-lymphocytes increase in number to fight against the invaded bacteria. It could also be interpreted that less or no breast feeding, ill-experience of the mother, or less care of the mother to her child; or lack of early vaccination of the babies etc... The gradual drop in infection rates at ages older than 24 months old had gone significantly and gradually lower and became even lower i.e. (8%) for older than 3 years which is in agreement with more recent work [12]. In children older than 24 months ages, when these positive septicemia children are compared against their counterpart negative children with the same ages, the differences appeared insignificant [p≤0.597]. The latter may look unexpected due to either inadequate sampling that produced a rather poor conclusion, or the results might have been compromised due to early treatment of babies with antibiotics. The expectation might have been significant due to the visible differences. Such a statement may represent a personal pre-conclusion which needs further investigation by expanding the comparisons to include more children with septicemia. Despite the fact that the infection proportion of septicemia between the two genders of children appeared almost 2/3 (37% male to 63% female) respectively; however, the difference between these two genders themselves was insignificant (p≤0.619). If so, then, it looks as there is no link between sepsis and gender factor and therefore the disease may be gender irrelevant. Sex and gender dimorphisms

are found in a large variety of diseases, including sepsis and septic shock which are more prevalent in men than in women [13]. Animal models show that the host response to pathogens differs in females and males where such a difference is partially explained by sex polarization of the intracellular pathways responding to pathogen–cell receptor interactions. These results clearly show the important of taking both age and gender into account when assessing changes in blood parameters in infected children, which would be the next goal to be investigated.

Generally, any subtle alteration in blood parameters may indicate a health disorder where the complete blood counting becomes a key factor for diagnosis. Any increase in WBC count called leukocytosis which indicates a range of health conditions i.e. microbial infection, inflammation, injury and immune system disorder [14]. Increase in WBC also means the immune system is activated to destroy an infection, a sign of physical or emotional stress, or particular types of cancer [15]. There is a general agreement that the normal number of WBCs in the blood ranges between 4,500-11,000x106/mL; however, it may slightly vary among different labs as some labs use different measurements or may test different specimens [16]. If the WBC count is above 20,000x109, it is important to investigate the differential to determine what kind of cells are seen [17]. The present results showed that WBC counts extremely and significantly elevated higher than normal value which may denote the severe invasion of bacteria to blood, particularly the granulocytes showed clear elevation. When the WBC count is just at borderline high, investigation of the type of WBCs (the differential) become so important to further confirm significance of the results. Unfortunately, no differential counting was done in this research i.e. neutrophil, which is specifically in charged in fighting the microbes and to engulf the invaded bacteria in the blood. However, the only WBC formed cells counted was lymphocytes which had elevated two fold. Lymphocytes normally represent 20-40% of circulating WBC. Hence, the occurrence of lymphocytosis often translates into an increase in the overall WBC count, and increase of lymphocytes occurs with certain acute and chronic infections (Abramson and Melton, 2000)[16]. Despite the fact that an increase in the account of lymphocytes, is considered normal in children less than 2 years of age; however, such an elevation in lymphocyte could be attributed to the activation of immune system in the infected children. Dendritic cells act as messengers between the innate and adaptive immune systems by presenting antigens to T-cells can also engulf and digest foreign particles, making them essential for identifying and responding to potential bodily threats [18].

Sometimes, a high WBC count is accompanied by anemia, that happens when bone marrow disease that's causing overproduction of WBC also causes underproduction of RBC[19]. Such results are obtained in the present work however, as in increase in WBC against drop in RBC count had occurred in septicemia but to confirm the conclusion perhaps further tests should be carried out including higher number of septicemia children. The number of RBC had significantly dropped down so as the hemoglobin in sepsis children which may denote the initiation to early anemia represents one of the key concerns of patients with sepsis. Recent studies have found that anemia can lead to poor

prognosis in patients with sepsis. The consequences of sepsis on RBC included reduced antioxidant status, changed hemoglobin and oxygen affinity, altered RBC size and shape and altered deformability [20]. The latter is in line with the present results as an insignificant drop in erythrocytes (RBC) counts in comparison with the control indicates an early anemia which in enhanced with the parallel drops in Hb% percentages.

Percentage of hemoglobin in RBC is generally around 34%, i.e. in mammals where the protein makes up about 96% of the RBC dry content, and around 34% of the total content [21]. A most recent study has shown that with the decrease of hemoglobin levels, the prognosis of patients with sepsis becomes worse and the mortality rate increases [20]. An insignificant drop in hemoglobin, parallel to a similar insignificant drop in RBC was detected in the present study denotes the partial impact on respiration rate that may, consequently, cause further health disorder in the sepsis children i.e. hypoxia etc. This is logic due to the correlation between the amount of hemoglobin carried up and distributed all over the body tissues by the RBC proportion in the blood. Hence, victims may suffer an extra health disorder due to an inadequate oxygen capacity inhaled and in reciprocal extra CO2 exhaled from the lungs. Accordingly, it is likely to attribute the increase in WBC and decrease in RBC to the failure of bone marrow in septicemia children to keep the levels of both types of blood cells on [22]. These results underline the importance of monitoring blood parameters in infected children, and suggest potential diagnostic markers for early detection of bacterial infections. The present results do confirm that most recent study of those changes detected in hemoglobin levels on admission were associated with the prognosis of sepsis patients, where the mortality of sepsis patients increased with decreasing hemoglobin levels [20]. Accordingly, an early attention to hemoglobin in sepsis may be beneficial to the prognosis of patients with sepsis. They also underline the importance of taking demographic and clinical factors into account when interpreting blood test results [23]. This would be our next goal as in this research it has not been taken into consideration due to the fact that the population of Kirkuk province is a multi-cultural society with intermingled races.

The mild or a slight increase in number of platelets (PLT) has been within the range; yet it reveals the impact of the bacteria on its population that may increase the possibility of blood clouting possibility in the children. The insignificant differences detected in erythrocytes and PLT, suggest that these parameters remain relatively stable across age groups. The risk of blood clout in the patients may represent a threat to death of victims if not treated. A continuous consideration in monitoring the blood parameters of CBC deems so important factor to be considered by general practitioners in updating and in treating the babies admitted in hospitals or private clinics in the city.

CONCLUSION

Fundamental Finding : The study concludes that conducting early blood analysis is a crucial step for health authorities when a newborn is admitted to the hospital. This approach allows for timely prognostic evaluation of potential infections, particularly those related to septicemia, as indicated by changes in blood parameters. **Implication :**

This finding highlights the necessity for medical institutions to prioritize immediate blood tests in neonatal care, as early detection of septic conditions could significantly improve treatment outcomes and reduce neonatal mortality. **Limitation :** However, the study does not explore the variability in diagnostic accuracy across different hospital settings or among diverse patient populations, which may affect the generalizability of the recommendation. **Future Research :** Further studies are needed to investigate the implementation of early blood analysis protocols in various clinical environments and to evaluate their effectiveness in predicting septicemia outcomes in a broader cohort of neonates.

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