Psychiatric Disabilities and Other Long-term Consequences of Childhood Bacterial Meningitis

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Background: Bacterial meningitis is known to cause hearing impairments and neurologic deficits; however, less is known regarding psychiatric disabilities. In this study, we assessed psychiatric disabilities and other long-term consequences of childhood bacterial meningitis.

Methods: From a previously validated dataset, we selected children having had bacterial meningitis. We then reviewed medical records and child health records from discharge onwards to identify disabilities. We calculated the occurrence of disabilities with a 95% confidence interval (CI), and we used a χ^2 test to assess possible individual risk factors associated with occurrence of disabilities.

Results: Of the 80 children included in this study, permanent disabilities not attributed to preexisting diseases were noted in 56% (CI: 45–67) during the mean observation period of 19 years and 2 months. Psychiatric disease was diagnosed in 30% (CI: 21–41), and another 5% (CI: 2–13) were under ongoing investigations for symptoms of psychiatric disease. Hearing impairments affected at least 30% (CI: 20–40), and neurologic deficits affected at least 23% (CI: 15–34). While other disabilities were often detected within the first year, psychiatric disabilities were detected after a mean time period of 14 years (CI: 11:1–16:11). Although some associations were noted, no individual risk factor was able to predict the occurrence of disabilities.

Conclusions: Psychiatric disabilities affect more than one-third of survivors and are among the most common long-term consequence of childhood bacterial meningitis. Late discovery and predictive difficulties call for a revision of current guidelines to include a specific long-term strategy for detecting psychiatric disabilities.

Key Words: bacterial meningitis, children, disabilities, neurodevelopmental disorders, psychiatric disease

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Bacterial meningitis is a severe infection and is known to cause hearing impairments and neurologic deficits in survivors.[1,2] However, less is known regarding the risk of psychiatric disabilities.

The mortality rate in childhood bacterial meningitis is around 5% in high-income countries and 20%–40% in low- and middle-income countries.[3] Among survivors, the occurrence of permanent disabilities has been reported to be around 20%.[4] Based on previous knowledge of hearing impairments and neurologic defects, follow-up protocols often include a hearing test and a follow-up neurologic assessment by a pediatrician.[5–9] Today, no major international guidelines include a routine follow-up appointment aimed at specifically detecting psychiatric or neuropsychiatric disabilities.[5–9]

Recently, neuropsychiatric disabilities such as learning difficulties and reduced quality of life due to lack of energy, increased anxiety, and social difficulties have been reported in survivors.[10] Due to a lack of large studies or studies with long observational periods, the actual risk is difficult to determine. However, it has been estimated that 5%–39% of surviving children may experience psychiatric difficulties.[11–13]

These recent findings raise the important question of whether psychiatric disabilities following childhood bacterial meningitis are missed today, resulting in unnecessary suffering. In this study, we aimed to assess psychiatric disabilities and other long-term consequences of bacterial meningitis in childhood.

MATERIALS AND METHODS

In this retrospective cohort study, we used an existing dataset combined with medical records and child health records to investigate psychiatric disabilities and other long-term consequences of childhood bacterial meningitis.

Dataset and Case Selection Criteria

We used a dataset containing 1143 cases of severe infections in previously healthy children as well as children with preexisting diseases occurring in 1986 to 2015 in the Västerbotten region, as previously described.[14–16] From this dataset, we selected validated cases of bacterial meningitis in 1-month- to 17-year-old surviving children residing in the Västerbotten region (Table 1).

Exclusion Criteria

This study did not have any general exclusion criteria. Children with disabilities due to preexisting diseases were excluded in the analysis of their specific preexisting disabilities. Otherwise, these children were included in all analyses.

Variables and Data Collection

The dataset contained information obtained from the patients' medical records on preexisting diseases together with

TABLE 1. Validation Criteria for Bacterial Meningitis

Criteria	Description
Diagnosis	An ICD diagnosis of bacterial meningitis (ICD-8/9: 036 and 320, ICD-10: A39 and G00)
Bacterial culture	A positive cerebrospinal fluid culture
Clinical presentation	A clinical presentation consistent with bacterial meningitis as defined by the Bacterial Meningitis Score[17] or the clinical decision rule by Oostenbrink et al[18]

This table shows the validation criteria for bacterial meningitis used in our study. For a case to be validated as bacterial meningitis, at least 2 of the 3 criteria had to be fulfilled.

ICD indicates International Classification of Diseases.

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clinical signs, symptoms, and laboratory findings at admission to the hospital as well as any complications or disabilities noted during the hospital stay.

Using a standardized protocol, we collected information on disabilities and other medical conditions by systematically reviewing medical records from discharge until December 31, 2017. During this process, medical records were retrieved from the following clinics within the Västerbotten region: pediatrics, child health, otorhinolaryngology, neurology, neurosurgery, child and adolescent habilitation, rehabilitation, psychiatry, and child and adolescent psychiatry.

Cerebral function was graded retrospectively using the Pediatric Cerebral Performance Category (PCPC) scale[19] (Table 2). Occurrence of psychiatric disease was defined as having been diagnosed with a psychiatric disease according to the Diagnostic and Statistical Manual of Mental Disorders. Hearing impairments were defined according to the International Classification of Functioning Disability and Health by the World Health Organization (WHO) and graded into "mild" (26–40 dB reduction), "moderate" (41–60 dB reduction), "severe" (61–80 dB reduction), and "profound" (>80 dB reduction).[20] Additionally, "disabling hearing loss" was defined as bilateral impairments of at least 30 dB.[20] Finally, the occurrence of neurologic deficits was based on recordings of such deficits in the patients' medical records or child health records.

To ensure that no patient had relocated from the Västerbotten region during the observational period, the Swedish Population Register was used. In case this had occurred, the registered relocation date was noted as the end of the observation period for that patient.

Statistics

We performed all statistical analyses in IBM SPSS Version 24 (IBM Corp., Armonk, NY). The χ^2 test was used for categorical variables, and Levene's test of equality combined with a *t* test was used for continuous variables, both presented with a 95% confidence interval (CI). Finally, we used the χ^2 test to assess the effect of risk factors. In this analysis, a *P* value below 0.05 was considered significant.

Ethics

Our study was approved by the Regional Ethics Board in Umeå (08-208 M, 2015/336-32, and 2017/182-31).

TABLE 2. Pediatric Cerebral Performance Scale

Category	Description
1: Normal	Interacts at an age-appropriate level and -Attends regular school with age-appropriate grades, and -Has no neurologic deficits
2: Mild disabilities	Interacts at an age-appropriate level and -Attends regular school, but grades are not age appropriate, or -Has mild neurologic deficits
3: Moderate disabilities	Can independently perform age-appropriate activities of daily life and -Attends special education, or -Has learning deficits
4: Severe disabilities	Is dependent on others for activities of daily life that others at that age can perform independently
5: Coma	Is in any degree of coma
6: Brain death/death	Is brain dead or dead

This table shows the criteria and grading system for the Pediatric Cerebral Performance Scale (PCPC)[19] used in our study.

RESULTS

Of the 104 validated cases of bacterial meningitis, 4 cases constituted repeated episodes in the same child and were therefore excluded. An additional 7 cases were excluded due to death during the hospital stay, and 13 cases due to the child not residing in the Västerbotten region. The remaining 80 cases were all included in our study.

TABLE 3. General Features, Treatment Strategies During the Hospital Stay and Short-term Outcome

Patients' characteristics (N = 80)	
Age at admission, mean (yr:mo)	3:6
Sex distribution (%)	–
Girls	49
Boys	51
Duration of illness before admission, mean (d)	1.8
Preexisting diseases (%)	24
Causative pathogen (N = 80)	
H. influenzae (%)	50
S. pneumoniae (%)	26
N. meningitidis (%)	9
Other pathogens (%)*	6
Treatment strategies (N = 80)	
Initial antibiotic treatment (%)	–
Cephalosporins	92
Carbapenems	3
Addition of ampicillin	28
Duration of antibiotic treatment, mean (d)	12.4
Addition of corticosteroids (%)	63
Addition of antiviral therapy (%)	23
Intensive care (%)	41
Invasive intracranial pressure monitoring or management (%)†	5
Other neurosurgical procedures (%)‡	5
Duration of hospital stay, mean (d)	14.6
Complications during the hospital stay (N = 80)	
Intracerebral structural injury (%)§	11
Pathologic neurologic findings (%)	19
Repeated or prolonged seizures (%)	19
Pathologic electroencephalogram (%)	1
Other complications (%)¶	28
Cerebral function at discharge‖ (N = 80)	
No disabilities (PCPC category 1) (%)	78
Disabilities (%)	–
Mild (PCPC category 2)	16
Moderate (PCPC category 3)	6
Severe (PCPC category 4)	0

This table shows the general features for the patients included in our study, treatment strategies during the hospital stay, and the short-term outcome. All values are given as percentages or as means. The number of included patients for each analysis is shown in brackets.

*This category included 3 cases of group B streptococci and 1 case each of group A streptococci and *Escherichia coli*.

†This category included the use of either an intracerebral pressure monitor or an external ventricular drain.

‡This category included surgical debridement of intracerebral aseptic hygroma with or without placement of a temporary drain.

§This category included 6 cases of aseptic hygromas, 2 cases of ischemic injury, and 1 case of subdural hematoma and hydrocephalus. All cases of intracerebral structural injury were diagnosed via brain computed tomography except in 1 case of aseptic hygroma diagnosed via repeated brain ultrasounds and 1 case of ischemic injury diagnosed via magnetic resonance.

¶This category included 5 cases of respiratory problems, 4 cases of reactive arthritis, 4 cases of coagulation problems, 3 cases of herpes stomatitis or other peripheral viral infections, 2 cases of kidney failure, 2 cases of syndrome of inappropriate antidiuretic hormone secretion, 1 case of osteitis, 1 case of skin necrosis, 1 case of vision impairment, 1 case of septic arthritis, and 1 case of hydrocele.

‖Cerebral function at discharge was retrospectively graded using the Pediatric Cerebral Performance Category Scale (PCPC)[19] where a normal function was defined as PCPC category 1 and disabilities were defined as PCPC categories 2–5. In 5 patients, these disabilities were previously known and were due to preexisting diseases.

PCPC indicates Pediatric Cerebral Performance Category Scale.

The observational period ranged from 11 months to 31 years and 8 months, with a mean of 19 years and 2 months. During this period, a permanent disability not attributed to preexisting diseases affected 56% (CI: 45–67) of the included patients. Additionally, another 16% (CI: 9–25) had transient disabilities.

Patient Characteristics

Most patients were younger than 5 years of age when contracting bacterial meningitis (Table 3). Of the 80 cases included in our study, preexisting diseases of varying severity were common and affecting 19 children. Of these, 7 children already had developmental deficits and were therefore excluded in the analyses of neurologic and psychiatric disabilities. Of these, 3 children were born prematurely (of whom one also had Down's syndrome), 2 children had deficits due to intracerebral structural injury, and 1 had deficits due to an astrocytoma. Finally, 1 child had a severe developmental disorder named LHX3 syndrome. Of these 7 children, 1 also had hearing impairments and 2 had epilepsy. The remaining 12 patients with preexisting diseases were 2 children having had skull base fractures of whom 1 also had a hearing impairment, 2 children with epilepsy, 4 children with respiratory conditions, 3 children with autoimmune disease, and 1 child who was immunosuppressed due to medications.

In-hospital treatment included broad spectrum antibiotics, corticosteroids, and initial antiviral therapy, among others (Table 3). Complications occurred in 45%, and these were mostly pathologic neurologic findings or repeated or prolonged seizures. Intracerebral structural injuries were seen in 9 patients, and at discharge, 22% of all patients had reduced cerebral function defined as PCPC category 2–5 (Table 3). During the observation period, 2 patients developed severe nonrelated diseases—1 with lymphoma and 1 with rheumatic disease. In both patients, permanent disabilities had been detected several years before being diagnosed with these diseases. Additionally, 7 patients received medical care for accidents involving head trauma resulting in concussions during the observational period. Of these, 4 already had disabilities that had been discovered beforehand, whereas 1 was diagnosed with attention deficit hyperactive disorder (ADHD) 9 years and 5 months after the accident.

Cerebral Function and Concentration or Learning Difficulties

One year after discharge, reduced cerebral function was noted in 34% (CI: 24–46) of the patients without previous developmental deficits. Later, close to half of the patients had reduced cerebral function (Table 4).

Concentration or learning difficulties were present in 21% (CI: 13–31), and these problems were first brought to the attention of a health care provider after a mean time period of 12 years and 3 months (CI: 8:1–16:5) after discharge. Neuropsychiatric investigations were initiated in 10 patients, of which 6 had shown the occurrence of neurodevelopmental disorders and 4 were still ongoing at the end of the observation period.

Psychiatric Disabilities

In total, 30% (CI: 21–41) of patients without previous developmental deficits were diagnosed with psychiatric disease during the observation period (Table 4). Additionally, another 5% (CI: 2–13) had symptoms of psychiatric disease that were not yet diagnosed. Anxiety disorders were noted in 23% (CI: 15–34) and were the most common type of psychiatric disease, followed by depression in 19% (CI: 11–29) and sleep disorders in 15% (CI: 8–25).

In those patients having an observation period of at least 10 years, the occurrence of psychiatric disease increased further to 37% (CI: 25–50).

Symptoms of psychiatric disease were first brought to the attention of a health care provider after a mean time period of 14 years (CI: 11:1–16:11) after discharge. Eating disorders and obsessive-compulsive disorders tended to debut earlier, whereas anxiety disorders, depressive disorders, neurodevelopmental disorders, psychotic disorders, and sleep disorders had a later debut (Table 5).

Hearing Impairments

A permanent hearing impairment of more than 25 dB was noted in 36% (CI: 25–48) of the 64 patients without previous hearing impairments undergoing a hearing test. This is equivalent to 30% (CI: 20–40) of the entire group of patients without previous hearing impairments.

Bilateral hearing impairments affected 6 patients, of whom 3 met the definition of disabling hearing loss,[20] which was equivalent to an occurrence of 4% (CI: 1–10). Consequently, 1 patient received conventional hearing aids, and 3 patients received cochlear implants.

Hearing impairments were detected at a mean of 10 months (CI: 4–22) after discharge, with 94% (CI: 81–99) being detected within 1 year.

Neurologic Deficits and Epilepsy

Permanent neurologic deficits were noted in 23% (CI: 15–34) of the patients without previous developmental deficits.

Neurologic deficits were detected after a mean time period of 1 year and 4 months (CI: 0:8–2:0) after discharge. In 61% (CI: 42–77), these disabilities were detected within 1 year. Speech disorders were often detected later, with only 25% (CI: 9–49) being detected during the first year.

In addition to neurologic deficits, 11% (CI: 5–19) of patients without previous epilepsy were diagnosed with this disorder at a mean of 7 years and 6 months (CI: 0:11–15:0) after discharge.

TABLE 4. Cerebral Function at Discharge and During the Observation Period

Disabilities	Discharge (N = 73)	Year 1 (N = 73)	Year 5 (N = 69)	Year 10 (N = 57)	Year 15 (N = 49)	Year 20 (N = 43)	Year 25 (N = 33)	Year 30 (N = 10)
No disabilities (PCPC category 1) (%)	82 (72–90)	66 (54–76)	54 (42–65)	56 (43–68)	57 (43–70)	51 (37–66)	48 (32–65)	40 (15–70)
Mild disabilities (PCPC category 2) (%)	15 (8–25)	29 (19–40)	38 (27–49)	37 (25–50)	41 (28–55)	44 (30–59)	39 (24–56)	40 (15–70)
Moderate disabilities (PCPC category 3) (%)	3 (1–8)	4 (1–11)	7 (3–15)	5 (2–13)	2 (0–9)	5 (1–14)	12 (4–26)	10 (1–38)
Severe disabilities (PCPC category 4) (%)	0 (–)	1 (0–6)	1 (0–7)	2 (0–8)	0 (–)	0 (–)	0 (–)	0 (–)
Coma (PCPC category 5) %	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Brain death or death (PCPC category 6) %	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)	10 (1–38)

This table shows cerebral function at discharge and during the observation period in patients without previous developmental deficits, retrospectively graded using the PCPC.[19] Occurrence is presented as a percentage followed by a 95% confidence interval in parenthesis. The number of included patients for each analysis is shown in brackets.

PCPC indicates Pediatric Cerebral Performance Category Scale.

TABLE 5. Psychiatric Disease and Symptoms of Psychiatric Disease

Psychiatric disease* (N = 73)	Occurrence (%)	Age, mean (yr:mo)	From discharge, mean (yr: mo)
Neurodevelopmental disorders	8 (4–16)	20:3 (12:7–27:10)	19:3 (12:2–26:4)
Attention deficit hyperactivity disorder	7 (3–14)	–	–
Autism spectrum disorders	4 (1–11)	–	–
Psychotic disorders	4 (1–11)	23:9 (10:3–37:2)	19:6 (0:0–47:5)
Depressive disorders	19 (11–29)	21:8 (19:3–24:0)	18:2 (14:1–22:4)
Anxiety disorders	23 (15–34)	20:7 (17:9–23:4)	18:1 (14:10–22:4)
Obsessive-compulsive disorders	3 (1–8)	16:10 (0:0–56:7)	16:0 (0:0–49:8)
Eating disorders	4 (1–11)	15:2 (11:8–18:7)	13:7 (10:7–16:8)
Sleep disorders	15 (8–25)	21:2 (16:7–25:10)	19:9 (15:2–24:4)
Personality disorders	1 (0–6)	25:3 (–)	14:4 (–)
Concentration and learning difficulties† (N = 73)	Occurrence (%)	Age, mean (yr:mo)	From discharge, mean (yr:mos)
Concentration difficulties	18 (10–28)	17:4 (13:5–21:2)	13:6 (9:1–17:11)
Learning difficulties	11 (5–20)	9:8 (2:2–17:1)	9:2 (1:3–17:2)
Need for special education	8 (4–16)	16:9 (9:1–24:5)	11:10 (2:1–21:6)
Suicidality† (N = 73]	Occurrence (%)	Age, mean (yr:mo)	From discharge, mean (yr:mo)
Suicidal tendency	10 (4–18)	19:6 (15:4–23:8)	17:9 (13:2–22:3)
Suicide attempts	1 (0–6)	20:6 (–)	11:8 (–)
Crime and substance dependency† (N = 73]	Occurrence (%)	Age, mean (yr:mo)	From discharge, mean (yr:mo)
Crime victims	4 (1–11)	–	–
Crime perpetrator	3 (1–8)	–	–
Alcohol or drug dependency	5 (2–13)	–	–

This table shows the occurrence of psychiatric disease and symptoms noted during the observation period in patients without previous developmental deficits. Occurrence is presented as percentages, and age at detection and duration from discharge to detection are presented as means in years and months, all followed by a 95% confidence interval presented in parenthesis. The number of included patients for each analysis is shown in brackets.

*This category only included patients having at least 1 psychiatric disease being diagnosed according to the DMS criteria. In several cases, the patients had more than 1 diagnosis of psychiatric disease.

†These categories also included patients not fulfilling the DSM criteria for psychiatric disease.

DSM indicates Diagnostic and Statistical Manual of Mental Disorders.

Detection of Disabilities at Scheduled Follow-up Appointments

Follow-up appointments at a pediatric clinic were scheduled for 91% (CI: 83–96) of all patients, involving a median of 2 appointments before the contact was discontinued. Additionally, 3 patients were referred to a child habilitation clinic, 2 patients to a neurosurgical clinic, and 1 to a child psychiatric clinic. A hearing test was performed during the hospital stay or shortly after discharge in 83% (CI: 73–90) of all patients. Most patients having neurologic deficits or hearing impairments were detected during the scheduled follow-up, whereas patients having psychiatric disabilities were not.

Detection of Disabilities at Regular Child Health Visits

Child health records were available for 66 patients, of whom 46 had no previous developmental deficits and contracted bacterial meningitis before having had their last regular child health visit. Of these, 16 children later developed psychiatric disease. However, only 4 were suspected of having delayed general development. The first 2 had disabilities already known at discharge or detected early during the scheduled follow-up. The third child had isolated neurologic deficits, and the fourth child was without disabilities, but both failed several developmental tests at their regular 4-year child health visit. In both cases, no action was taken. Several years later, 1 was diagnosed with an autism-like disorder and the other with ADHD. None of the remaining patients later developing psychiatric disabilities were suspected of having delayed general development during their regular child health visits.

Prediction of Disabilities

We identified several individual risk factors that were significantly associated with acquiring disabilities. Boys more often developed permanent hearing impairments compared with girls (46% vs. 15%; $P = 0.002$) as did patients having a duration of illness longer than 24 hours at admission compared with others (44% vs. 18%, $P = 0.013$). Cerebrospinal fluid glucose levels at admission were lower in patients later developing permanent disabilities (1.5 mmol/L vs. 2.5 mmol/L, $P = 0.012$) and patients later being diagnosed with psychiatric disease (1.1 mmol/L vs. 2.1 mmol/L, $P = 0.008$). Finally, permanent neurologic deficits more often occurred in patients having pathologic neurologic findings during the hospital stay (50% vs. 17%, $P = 0.009$), intracerebral structural injury (71% vs. 18%, $P = 0.002$) or reduced cerebral function at discharge defined as PCPC category 2–5 (62% vs. 15%, $P < 0.001$), compared with others.

No significant associations were noted for causative pathogen, nor any other factors besides these described above.

DISCUSSION

In this study, we show that permanent disabilities following childhood bacterial meningitis affected 56% (CI: 45–67) of survivors. Psychiatric disability was the most common disability, mostly in the form of anxiety disorders and depression, but concentration and learning difficulties were also common. Additionally, permanent disabilities also included hearing impairments and neurologic deficits. Whereas hearing impairments and neurologic deficits were diagnosed early, psychiatric disabilities were often diagnosed several years later.

Psychiatric Disabilities

To the best of our knowledge, no previous study has investigated the long-term occurrence of psychiatric disabilities following childhood bacterial meningitis. In our study, we noted an overall occurrence of psychiatric disease of 30% (CI: 21–41) and an occurrence of 37% (CI: 25–50) in patients having an observation period

of at least 10 years. This is substantially higher than in the general population. Because the occurrence of psychiatric disease varies depending on location, we compared our results with 2 previous studies also conducted in Sweden.[21,22] A self-reported occurrence of symptoms of psychiatric disease of 13%–20% was reported in a questionnaire study in persons 20–64 years of age.[21] However, that study might have overestimated the prevalence of psychiatric disease because patients experiencing symptoms of psychiatric disease might have been more likely to reply and might have reported minor symptoms not fulfilling the criteria for psychiatric disease.

Anxiety disorders noted in 23% (CI: 15–34) and depression noted in 19% (CI: 11–29) were the most common psychiatric diseases seen in our study. This is considerably higher compared with the 9.9% occurrence of anxiety disorders and 12.4% occurrence of depression observed in a large cohort study in primary healthcare including more than 5 million Swedish adults conducted in 2017.[22]

The 21% (CI: 13–31) occurrence of concentration or learning difficulties seen in our study is consistent with previous studies showing that many patients experience academic and behavioral limitations following childhood bacterial meningitis.[11] In our study, 14% (CI: 7–23) of the patients later took part in neuropsychiatric investigations resulting in 7% (CI: 3–14) being diagnosed with ADHD. This is higher compared with studies showing a prevalence of ADHD in Sweden of 2% in children 9–12 years of age and a prevalence of 0.5% in all age groups.[22–24]

With our study design, we cannot conclude whether psychiatric disabilities were present and missed during the initial follow-up or if they had a later debut. However, delayed diagnosis of psychiatric disability is a well-known problem, likely affecting this group of patients as well. There is often a long waiting period for starting an investigation, and the process itself can be time-consuming.[25] As several studies have shown, a delayed diagnosis can lead to insufficient treatment, ineffective assistance at school, unnecessary suffering, and heavy social burden.[26,27] To reduce the burden of psychiatric disability, early diagnosis is very important.[26–29]

For children with traumatic brain injury or malignancies, guidelines recommend neuropsychiatric investigations within 2 years of diagnosis and repeated follow-up appointments until adulthood.[30,31] Contrary to this, current guidelines for bacterial meningitis do not recommend either.[5–9] In our study, psychiatric disabilities were not detected during the scheduled follow-up nor were they detected at the regular child health visits. Additionally, no individual risk factor could identify children who later developed psychiatric disabilities. These results are strong indicators that current guidelines for bacterial meningitis should be revised to include specific long-term strategies to detect psychiatric disabilities.

Hearing Impairments

The 30% (CI: 20–40) permanent hearing impairment rate seen in our study is considerably higher than the 6%–16% reported previously.[4,12,32,33] This is likely due to those studies using a stricter definition than that of the WHO, as was used in our study. When comparing the occurrence of disabling bilateral hearing loss, the 4% (CI: 1–10) seen in our study is consistent with previous studies.[4]

Because hearing impairment is a well-known risk with bacterial meningitis, most guidelines recommend a follow-up hearing test.[5–9] The effectiveness of this strategy is exemplified in our study by an absolute majority of permanent hearing impairments being detected within the first year.

Neurologic Deficits and Epilepsy

Permanent neurologic deficits noted in 23% (CI: 15–34) of patients without previous developmental deficits are comparable to the 9%–23% occurrence seen in previous studies.[4,12,23,24] Most neurologic deficits in our study were detected within the first year after discharge indicating that the follow-up after bacterial meningitis is sufficient regarding the detection of neurologic deficits.

For epilepsy, the 11% (CI: 5–19) occurrence seen in our study is considerably higher than in previous studies.[4,12,23,24] A possible explanation is that epilepsy debuted on average 7 years and 6 months (CI: 0:11–15:0) after discharge in our study, whereas previous studies showing an occurrence of 2% only had an observation period of around 3 years.[4,12,23,24] It is therefore possible that previous studies underestimated the risk of epilepsy due to short observation periods.

Strengths and Weaknesses

This study's major strength is the long observation period, enabling disabilities with a later debut to also be detected. However, being a retrospective study, the lack of standardized protocols for clinical examinations and investigations could still result in disabilities being missed. Likewise, disabilities that the patient did not bring to the healthcare providers' attention would also have been missed. Together, these suggest that our study might underestimate the actual occurrence of disabilities following childhood bacterial meningitis. The retrospective approach using a historical material partly collected before general infant vaccinations against *H. influenzae* type b were introduced in the region in 1992 also resulted in a higher occurrence of bacterial meningitis caused by *H. influenzae* then what is common today. This might suggest a reduced transferability of our results. However, since we noted no significant differences when comparing different causative pathogens, nor any tendency toward this, we do not believe that this is the case. Finally, the lack of a control group limits the interpretation of our results.

CONCLUSIONS

Psychiatric disabilities affecting more than one-third of survivors are one of the most common long-term consequence of childhood bacterial meningitis. While hearing impairments and neurologic deficits are well known and often detected early, psychiatric disabilities are not. Late discovery and predictive difficulties call for a revision of current guidelines to include a specific long-term strategy to detect psychiatric disabilities.

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