BMJ Open

Healthcare needs, care use and health status outcomes in adults with Bardet-Biedl syndrome: a cross-sectional study in Norway

Cecilie Fremstad Rustad ,[1,2] Ragnheidur Bragadottir,[2,3] Hilde Nordgarden ,[4] Jeanette Ullmann Ullmann Miller ,[1] Mina Susanne Weedon-Fekjær ,[1] Shahrzad Arfa,[1] Pamela Marika Åsten,[4] Kristian Tveten ,[5] Charlotte von der Lippe ,[5] Solrun Sigurdardottir [1]

To cite: Rustad CF, Bragadottir R, Nordgarden H, *et al*. Healthcare needs, care use and health status outcomes in adults with Bardet-Biedl syndrome: a cross-sectional study in Norway. *BMJ Open* 2025;**15**:e095986. doi:10.1136/bmjopen-2024-095986

► Prepublication history for this paper is available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2024-095986).

Received 01 November 2024
Accepted 04 April 2025

[1]Centre for Rare Disorders, Oslo University Hospital, Oslo, Norway
[2]Faculty of Medicine, University of Oslo, Oslo, Norway
[3]Department of Ophthalmology, Oslo University Hospital, Oslo, Norway
[4]National Resource Centre for Oral Health in Rare Disorders, Lovisenberg Diakonale Hospital, Oslo, Norway
[5]Department of Medical Genetics, Telemark Hospital, Skien, Telemark, Norway

Correspondence to
Dr Cecilie Fremstad Rustad; cerus@ous-hf.no

ABSTRACT

Objectives This study aimed to determine healthcare needs and care use (provision of healthcare) in adults with Bardet–Biedl syndrome (BBS) and the associations between care use and physical functioning, health status outcomes and distress.

Design Cross-sectional study.

Setting Outpatient hospital visits.

Participants 30 adults with BBS were included (50% women, aged 20–69 years) and assessed with the Needs and Provision Complexity Scale, Short Physical Performance Battery, EuroQoL five dimensions with five severity levels (EQ-5D-5L) and Hospital Anxiety and Depression Scale.

Results The majority (80%) received disability benefits, 93% were overweight or obese and all had retinal dystrophy. Unmet needs (needs-gets) were found within the domains of rehabilitation (83%), social and family support (63%), healthcare (50%), personal care (47%) and the environment (40%). Significant correlations were observed between care use (gets) and worse physical performance (τ=−0.34, p<0.05), more problems with self-care (τ=0.47, p<0.01) and more problems with usual activities (τ=0.41, p=0.01). Compared with those in the general population, adults with BBS reported significantly more problems (EQ-5D-5L) with mobility, self-care, and usual activities (all p<0.001).

Conclusions Most adults with BBS have unmet physical, social and medical needs, with the majority having unmet rehabilitation needs that require special attention. Physical mobility and usual activities were correlated with the provision of healthcare. The complexity of BBS requires a multidisciplinary approach that focuses not only on the medical follow-up of the condition but also on healthcare needs for functional mobility and social care.

Trial registration number This study was registered at ClinicalTrials.gov, NCT05400278.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A multidisciplinary research team, including different healthcare professionals working in hospitals and resource centres for rare conditions, performed the evaluations.
⇒ Generic, validated outcome measures were used to estimate and interpret physical and mental health in the Bardet-Biedl syndrome population.
⇒ The small sample size limits the generalisability of the results and cannot be applied to children.
⇒ Data were self-reported, which might result in participants underestimating their problems.

INTRODUCTION

Healthcare needs are an increasingly important issue in rare disease research. Frequent healthcare problems among people with rare diseases include a lack of appropriate access to diagnosis and a lack of treatment options.[1 2] Rare diseases, defined in Europe as conditions with a prevalence of less than 1:2000 people, affect approximately 300 million individuals worldwide.[3–5] Many rare diseases are chronic, progressive, complex and disabling, and the rarity of each of the ~7000 rare diseases makes them difficult to diagnose.[6] Studies have shown that health professionals and general practitioners lack knowledge about rare diseases and lack confidence in providing care, transitioning care and coordinating the care of people with rare diseases.[7–9] Thus, individuals with rare diseases and their families unsurprisingly may face specific challenges when they seek information and support within health services. Delays in diagnosis and a lack of information about the diagnosis are shared challenges.[10] Furthermore, inequity in access to treatment and a lack of multidisciplinary care are health-related challenges that individuals with rare diseases may encounter.[11–14]

One chronic, complex rare disease is the primary ciliopathy named Bardet-Biedl

syndrome (BBS). This syndrome is characterised by retinal dystrophy, postaxial polydactyly, obesity, hypogonadism, renal abnormalities and cognitive impairment.[15 16] The prevalence of BBS is estimated to be 1 in 160 000 in Northern European populations.[17] The management of BBS poses challenges to health services because of the complexity of this condition, heterogeneity of the clinical phenotype and limited treatment options.[18] Treatment for BBS-related rod-cone dystrophy is not available,[15] whereas the treatment options for obesity, diabetes and kidney failure are the same for people with BBS as for those in the general population. More recently, individuals with BBS who are obese might be eligible for treatment with the melanocortin 4 receptor agonist setmelanotide if the treatment is available in the country where they live and if they fulfil the criteria for treatment.[19–21] Other management strategies are symptomatic, for example, special education for cognitive impairment and training for visual loss.[22] Because treatment options for BBS are limited, a personalised clinical approach is relevant to match individual needs.[18] Therefore, diagnostics, prevention, treatment and follow-up are adapted to the biological condition of the individual. Multiple health needs have been identified in BBS, including vision-related needs,[23] oral care needs,[24] difficult airway management,[25] type 2 diabetes mellitus needs[26] and problems accessing health services or treatments.[27 28] Unmet needs have been recognised regarding targeted treatments for hunger, hyperphagia and obesity.[29] An unmet need can be defined as 'difficulties receiving service in response to problems that significantly interfere with daily life'.[30] Adults with BBS might, for example, experience the need for physical activity to achieve weight loss before kidney transplantation but do not understand that their obesity is one of the core features of BBS. The relationship between needs and health status in BBS needs to be better understood to address the unmet needs within the context of health status in order to improve healthcare. Despite the impact of BBS on the daily lives of individuals, to the best of our knowledge, no research has documented their unmet needs for healthcare or the support they need. This study aimed to determine healthcare needs and care use in adults with BBS in Norway and associations between care use and physical functioning, health status outcomes and distress.

METHODS

Participants

This study was performed to offer inclusion of all adults with BBS in Norway. Eligible individuals were recruited through a register at the Centre for Rare Disorders, Oslo University Hospital, Norway, and by advertisement on the Norwegian BBS Organisation's webpage. The inclusion criteria were: (1) a clinical and/or genetic diagnosis of BBS; (2) ≥16 years of age; (3) residence in Norway; (4) adequate knowledge of Norwegian for communication and understanding the questionnaires. The exclusion criterion was not having BBS. A clinical diagnosis meant fulfilling clinical criteria for BBS as outlined by Forsythe and Beales.[17] Informed consent was to be obtained from all participants prior to inclusion.

Norway had a population of around 5.5 million individuals in 2022. The national resource centre for BBS had 46 adults registered, and the Norwegian BBS Organisation had approximately 50 adult members with BBS. Based on this information, half the number of adults with BBS were estimated to participate, that is 25 individuals.

Study design and data collection

This study was designed as a cross-sectional study and was conducted at the level of specialised healthcare in Norway from January 2022 to March 2023. Data were collected at the Oslo University Hospital and Lovisenberg Diaconal Hospital, Oslo, Norway. Eye examination was performed by an ophthalmologist (RB). Clinical examinations and interviews were conducted by a physician (CFR or CvdL), including measuring height and weight and calculating body mass index (BMI (kg/m^2)). The questionnaires were read aloud by one of the clinicians and answered orally, and a physical performance test was undertaken. These questionnaires and measures are described below. The oral health examinations were performed by a dentist and a speech and language pathologist (HN and PMÅ) at the National Resource Centre for Oral Health in Rare Disorders, Lovisenberg Diaconal Hospital, Oslo, Norway. The general flow of the examinations over a 1-day visit included eye examinations, clinical examinations and interviews, questionnaires, physical performance tests and, finally, oral health examinations.

Patient and public involvement statement

Two members of the Norwegian organisation for BBS were closely involved in the planning of this study and were consulted to identify relevant research topics of interest to the organisation. Both members were asked to test out the questionnaires.

MEASUREMENTS

Demographics and clinical information

Demographic information was based on self-reports from participants. Information was collected regarding gender, age at diagnosis, education, employment, medical comorbidities and prior lifetime contact (yes, no) with health institutions (eg, child and youth psychiatry, services within education and psychology, district psychiatry, child habilitation and national service for special needs education). Education was defined as high school or less (13 years or less) or more than 13 years of education. Employment, including paid full-time (100% employment), part-time (<100% employment) or self-employment, was classified as 'employed'. Any type of unpaid work, for example, unemployed, support at the workplace, retirement, disability benefits or home workers, was

classified as 'unemployed'. In general, height and weight measurements were performed using a seca 704 s (seca GmbH & co. KG., Hamburg, Germany). Obesity was assessed using BMI. BMI was calculated from the participants' height and body weight. A BMI between 18.5 kg/m^2 and 25 kg/m^2 was considered normal weight, a BMI above 25 kg/m^2 but <30 kg/m^2 was considered overweight and a BMI above 30 kg/m^2 was considered obese.[31] Renal disease included prenatally described kidney abnormalities, kidney tumours, increased kidney blood parameters, any stage of kidney failure or having had a kidney transplant. High blood pressure included measured systolic blood pressure above 140 mm Hg, diastolic pressure above 90 mm Hg and/or treatment with blood pressure-reducing medication. Diagnosis of diabetes mellitus was registered and/or medications for diabetes (yes/no). Oral/dental abnormalities (yes/no) were assessed by a dentist and included, for example, overbite, overjet, open bite, crowding of teeth and small teeth.

Needs for healthcare and social services

The Needs and Provision Complexity Scale (NPCS)[32] was used to evaluate the level of unmet needs for healthcare and social services. The NPCS was developed in the UK to identify healthcare and social support needs among individuals with neurological conditions.[32] It has been translated and recently validated in Norway[33 34] and used in several populations, including individuals with Huntington's disease,[33 35] traumatic brain injuries[36] and myotonic dystrophy.[37] The NPCS has not previously been used in adults with BBS. In this study, we used the Norwegian version 1.0. The NPCS has two parts: part A (Needs, what the individual needs) was completed by two clinicians (CFR and SS) to evaluate each participant's needs for health and social care, and part B (Gets, what the individual gets) was recorded by the clinician based on the information provided by the participants with BBS to evaluate care use (provision of healthcare). The NPCS has a total score ranging from 0 to 50 and contains five domains, which are scored as follows: healthcare scored from 0 to 6, personal care scored from 0 to 10, rehabilitation scored from 0 to 9, social and family support scored from 0 to 13 and environment scored from 0 to 12. The NPCS includes 15 items, which are scored according to the highest level applicable as follows: medical care needs (0–3); skilled nursing needs (0–3); number of carers (0–2); care frequency (0–5); personal assistant/enabler (0–3); therapy disciplines (0–3); therapy intensity (0–3); vocational support/rehabilitation (0–3); social work case management (0–3); family carer support (0–3); respite residentially (0–3); respite as day care (0–2); advocacy (0–2); equipment (0–3); accommodation (0–9). Higher scores indicate higher levels of needs. The total Needs score is the number of scores added together for the needs items. The total Gets score is the number of scores added together for the gets items. The total NPCS score is either the total score for Needs or the total score for Gets. Unmet Needs (Needs-Gets) were calculated for the total scores and the five domain scores. The percentage of participants needing the services (NPCS items) was converted to a binary variable (0=no unmet need, 1=unmet need).[32] The Norwegian version of the NPCS has excellent inter-rater reliability for the total scores of the NPCS-Needs and the NPCS-Gets, with values of 0.911 and 0.987, respectively.[34]

Physical performance evaluation

The Short Physical Performance Battery (SPPB) is a group of measures that combines the results of a 4.0 metre walking test at a normal pace (walking test), five-times rising from a chair as fast as possible (sit-to-stand test) and a standing balance test in a two-legged stance.[38] In this study, the SPPB was used to evaluate physical performance according to the standard guided procedure.[38] Each test was scored from 0 to 4, and the total score ranged from 0 to 12. A higher SPPB score signifies better physical performance. In the current study, the SPPB mean scores were compared with the mean normative scores in adults aged >40 years from a Norwegian population-based study.[39]

Self-reported health status

The EuroQoL five dimensions with five severity levels (EQ-5D-5L) is a self-reported measure that is used to evaluate general health status. The EQ-5D-5L includes a visual analogue scale (VAS) with scores ranging from 0 (the worst health you can imagine) to 100 (the best health you can imagine). Permission to use the EQ-5D-5L was obtained from the EuroQoL Group, and the Norwegian version was used.[40] The VAS was explained orally to each participant because of their reduced vision, and they were asked to rate their perceived health on the day of testing. The EQ-5D-5L consists of five domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each domain has five levels ranging from 1 (no problems) to 5 (extreme problems/unable to). In this study, descriptive levels of each dimension were dichotomised to 'no problems' (level one) or 'any problems' (levels two to five) and compared with the Norwegian normative population.[41] Furthermore, the EQ-5D-5L index values, ranging from 0 (dead) to 1 (full health), were calculated based on the UK value set used in Norway.[41]

Self-reported psychological distress

The Hospital Anxiety and Depression Scale (HADS) was used to assess symptoms of anxiety and depression within the last 7 days.[42] The HADS includes an anxiety scale and a depression scale, each with seven items. Each item is scored on a 4-point scale, with the total scores for anxiety and depression ranging from 0

(best) to 21 (worst). A HADS score >7 points was used to identify individuals with symptoms of anxiety or depression.[43] The HADS mean scores were compared with the mean Norwegian population scores from the HUNT-4 study.[44]

Statistical analysis

Descriptions of the participants and questionnaires are provided with descriptive statistics, including means, medians and percentages. Shapiro-Wilk tests were performed to assess continuous data for normality. The NPCS domains, the EQ-5D-5L index score and the HADS score were not normally distributed, and these data were summarised as medians and IQRs. The mean and SD were also given for the NPCS to allow comparisons with previous studies. The χ^2 test was used for the differences between categorical variables. Comparisons between normally distributed continuous variables were performed with Student's t test, whereas the Mann-Whitney U test was used for non-parametric variables. The Wilcoxon signed rank test for non-normally distributed variables was chosen to explore pairwise differences between the NPCS 'Needs' and 'Gets'. Kendall's tau-b correlation coefficient (τ) was used to evaluate bivariate correlations between age, kidney disease, high blood pressure, obesity, the HADS subscales, the SPPB total score and the five domains of EQ-5D-5L with the five NPCS Gets subscales, with 1000 bootstrapped samples. All p values <0.05 derived from two-sided tests were considered statistically significant. Because this study is observational with a small sample size, Bonferroni correction was not used, as it may overcorrect and increase the risk of type 2 error. Statistical tests were conducted with SPSS, V.29.0 (SPSS Statistics, IBM Corporation, Chicago, Illinois, USA).

RESULTS

Study sample characteristics

46 individuals were invited to participate. One person died shortly after the invitations were sent out, and one was excluded because of not having BBS. 30 individuals participated in this study with a response rate of 68% (30/44). When those who consented to participate (n=30) and non-participants (n=14) were compared, no differences in age (p=0.660) or sex (p=0.88) were identified.

Table 1 shows the characteristics of the 30 adult participants (mean age (±SD) 39.8±13.6, age range 20–69 years, 50% women). No sex differences were observed in any of the demographics (not shown). Overall, 17% of the participants were employed, either full-time or part-time, one had retired and the majority (80%) were receiving disability benefits. Four participants were offered the option of a home visit because they were unable to travel. They did not have an ophthalmology or oral exam.

Table 1 Demographics and characteristics of adults with Bardet-Biedl syndrome (n=30)

	Total
Males	15 (50%)
Age at inclusion*	39.8 (13.6)
Age diagnosed with BBS†	9 (13.5)
Marital status single	26 (87%)
Living independently or with a spouse or partner	18 (60%)
Living with parents or in care home	12 (40%)
Education (≤13 years)	27 (90%)
Employed (full time, part time)	5 (17%)
Disability benefits (full time)	24 (80%)
Body mass index	37.9 (11.1)
Overweight or obesity	28 (93%)
Retinal dystrophy‡	30 (100%)
Oral/dental abnormalities (n=26)	20 (77%)
Renal disease	8 (27%)
High blood pressure	20 (67%)
Diabetes	7 (23%)
Child mental health service	6 (20%)
Educational-psychological service	21 (70%)
Adult mental health clinic	4 (13%)
Needs and Provision Complexity Scale†	
Clinical version (part A *Needs*)	
Total Needs score (score 0–50)	17.0 (8)
Healthcare (score 0–6)	2.0 (1)
Personal care (score 0–10)	5.0 (3)
Rehabilitation (score 0–9)	5.0 (3)
Social and family support (score 0–13)	1.5 (2)
Environment (score 0–12)	4.5 (3)
Patient version (part B *Gets*)	
Total Needs score (score 0–50)	12.0 (6)
Healthcare (score 0–6)	2.0 (2)
Personal care (score 0–10)	3.0 (4)
Rehabilitation (score 0–9)	3.0 (2)
Social and family support (score 0–13)	0.0 (2)
Environment (score 0–12)	3.0 (3)

*Scores presented as mean (±SD).
†Scores presented as median (IQR).
‡Including self-reported retinal dystrophy in four individuals.
Notes, Discrete variables presented as number (percentages); Notes, Needs indicates that adults with BBS need this health service. Gets indicates that adults receive this health service (provision).

All participants had retinal dystrophy (including self-reports from the four home visits), and 93% were overweight or obese (BMI above 25 kg/m^2). Oral/dental abnormalities were more common in men than

Table 2 Differences between health service needs (part A) and gets (part B) according to the Needs and Provision Complexity Scale (n=30)

	Needs-Gets	Unmet needs†
	Median (IQR)/(range)	n (%)
Total NPCS (score 0–50)	4.0 (4.3)/(0–16)**	29/30 (97%)
Healthcare (score 0–6)	0.5 (1)/(-1–2)*	15/30 (50%)
Personal care (score 0–10)	0.0 (2)/(-1–5)*	14/30 (47%)
Rehabilitation (score 0–9)	2.0 (2)/(0–8)**	25/30 (83%)
Social and family support (score 0–13)	1.0 (1.3)/(-1–4)**	19/30 (63%)
Environment (score 0–12)	0.0 (1)/(0–4)*	12/30 (40%)

Needs indicates that adults with BBS need this health service. Gets indicate that adults receive this health service (provision). Unmet needs are the difference between Needs and Gets.
*p<0.01, **p<0.001 with the Wilcoxon signed rank test.
†Proportion of participants with a higher score on the NPCS Needs than the NPCS Gets.

in women. Two-thirds had high blood pressure, 27% had renal disease and 23% were diagnosed with type 2 diabetes. Four individuals had both renal disease and type 2 diabetes. The need for mental health services during childhood was reported by 20% of the participants, and 70% had been followed up by educational-psychological services in the school system. Moreover, 13% reported follow-ups with psychiatric services during adulthood.

The data for the NPCS are summarised in table 1. The median overall score for the NPCS (Needs) was 17.0 (IQR=8), and for the NPCS (Gets), it was 12.0 (IQR=6).

Unmet needs

As shown in table 2, clinicians (Needs) scored higher on all five domains compared with self-rated (Gets) scores. The Wilcoxon signed rank sum test confirmed the presence of significantly different pairwise comparisons between the measures of clinicians (NPCS Needs) compared with those of self-reports (NPCS Gets) (total (p<0.001); healthcare (p=0.002); personal care (p=0.001); rehabilitation (p<0.001); social and family support (p<0.001); environment (p=0.002); see table 2). Most participants (97%) were found to have unmet needs. The majority had unmet needs for rehabilitation (83%), followed by unmet social and family support needs (63%), healthcare needs (50%), personal care needs (47%) and environmental needs (40%).

Figure 1 illustrates the proportions of unmet needs across all 15 items of the NPCS, using the binary variable described in the methods. Between 50% and 77% of the participants were found to have insufficient professional healthcare (eg, medical care, social workers, physiotherapists, psychologists, occupational therapists, dieticians and dentists).

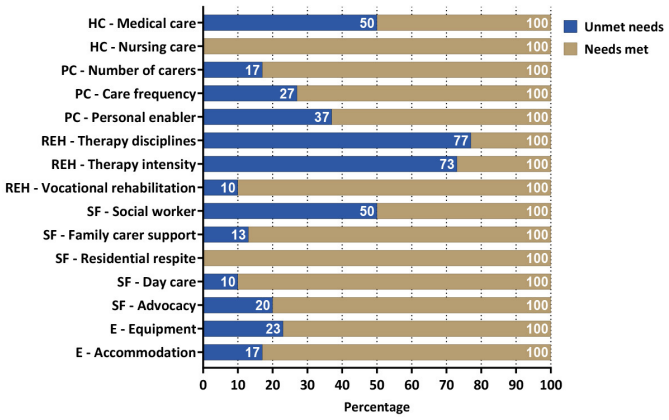

Figure 1 Percentage of unmet and met needs of the 15 items of the Needs and Provision Complexity Scale. E, environment domain; HC, healthcare domain; PC, personal care domain; REH, rehabilitation domain; SF, social and family support domain.

Differences in outcome measures of health status, distress and physical performance

Table 3 presents the results for the EQ-5D-5L, HADS and SPPB in comparison with normative data, using online calculators for two sample t-tests and χ^2 tests. The BBS population reported significantly more health problems (EQ-5D-5L) in terms of mobility, self-care and usual activities as well as significantly lower levels of general health (all p<0.001) than the general Norwegian population.[41] The BBS population reported significantly lower scores (ie, better mental health) on the three HADS scales (p<0.05) than the adult population in the HUNT-4 study.[44] The HUNT-4 study has published data on the HADS and is considered representative of health problems of the total adult population in Norway.[45] Notably, four adults with BBS (13%) were identified as having potential anxiety (score >7), and only one individual (3%) had potential depression (score >7). Finally, significant differences (p<0.001) were found for comparisons on levels of physical performance. The general population had much higher levels of physical functioning.[39]

Notably, two participants with BBS were unable to perform the SPPB test because they were unable to stand without support and were therefore given a total score of zero.

Correlations between care use (NPCS Gets) and health status outcomes

The healthcare subscale of the NPCS (table 4) was correlated with having more problems with usual activities (τ=0.41, p=0.01). The personal care subscale was correlated with worse physical performance (τ=–0.34, *p*0.05) and having more problems with self-care (τ=0.47, p<0.01). The correlation analyses revealed no associations between the provision of rehabilitation, social/family support and environment with any of the health status outcomes.

Table 3 Comparisons for outcome measures (EQ-5D-5L, HADS, SPPB) for the BBS population (n=30) and the Norwegian normative data

	BBS (n=30)	Normative data (n=3120)	
EQ-5D-5L domains	Any problems, n (%)	Any problems, n (%)*	P value
Mobility	16 (53%)	562 (18.0%)	<0.001
Self-care	7 (23%)	227 (7.3%)	<0.001
Usual activities	16 (53%)	756 (24.2%)	<0.001
Pain/discomfort	19 (63%)	1937 (62.1%)	0.888
Anxiety/depression	13 (43%)	1104 (35.4%)	0.365
	BBS, mean (SD)	Expected, mean (SD)*	
EQ-5D-5L VAS scale (score 0–100)	63.8 (21.5)	77.9 (18.3)	<0.001
EQ-5D-5L index score (score 0–1)	0.79 (0.18)	0.81 (0.20)	0.585
	BBS, mean (SD)	Expected, mean (SD)†	
HADS-total score	5.00 (6.01)	7.68 (5.66) n=40 648	<0.01
HADS-anxiety	3.13 (3.90)	4.40 (3.46) n=41 133	0.04
HADS-depression	1.87 (2.62)	3.30 (2.96) n=39 573	<0.01
	BBS, mean (SD)	Expected, mean (SD)‡	
SPPB-total score	6.7 (3.5)	11.4 (1.3) n=7474	<0.001

Comparisons between our BBS population and the general Norwegian population were conducted using online calculators for two sample t-tests and χ^2 tests.
*Derived from Garratt *et al*.[41]
†Derived from HUNT-4 study.[44]
‡Derived from Bergland *et al*.[39]
BBS, Bardet-Biedl syndrome; HADS, Hospital Anxiety and Depression Scale; SPPB, Short Physical Performance Battery; VAS, visual analogue scale.

DISCUSSION

This study focused on the healthcare needs of adults with BBS in Norway. In this nationally representative cross-sectional study, we found that a substantial proportion of adults with BBS who need supportive health services do not receive such services. Significant discrepancies were identified between needs (clinicians' ratings) and gets (participants' ratings), indicating that a majority had unmet needs related to the domains of health and personal care as well as social and supportive care. Several

Table 4 Correlation analysis between NPCS (Gets), HADS, SPPB and EQ-5D-5L and demographics in the total sample (n=30)

	Healthcare	Personal care	Rehabilitation	Social/ family support	Environment
	τ	τ	τ	τ	τ
Age	0.27	0.10	0.15	0.01	−0.21
Kidney disease (0=no, 1=yes)	0.27	−0.10	−0.16	−0.17	−0.24
High blood pressure (0=no, 1=yes)	0.27	0.21	0.04	−0.14	0.17
BMI	0.09	0.15	−0.21	−0.13	0.18
HADS anxiety	−0.20	0.10	0.16	−0.03	−0.11
HADS depression	−0.21	0.14	0.04	0.05	−0.14
SPPB total score	−0.20	−0.34*	−0.09	−0.24	−0.05
EQ-5D-5L mobility	0.28	0.07	−0.12	0.03	−0.14
EQ-5D-5L self-care	0.14	0.47**	0.14	0.21	0.22
EQ-5D-5L usual activity	0.41*	0.21	0.02	0.12	−0.17
EQ-5D-5L pain/discomfort	0.21	−0.03	−0.28	0.01	−0.11
EQ-5D-5L anxiety/depression	−0.08	0.25	0.08	0.09	−0.10

Correlation calculated with Kendall's tau beta correlation coefficient (τ). Bootstrapping with 1000 samples.
*p<0.05; **p<0.01.
HADS, Hospital Anxiety and Depression Scale; NPCS, Needs and Provision Complexity Scale; SPPB, Short Physical Performance Battery.

key findings are noteworthy. First, rehabilitation needs were rated as the greatest unmet needs overall. This demonstrates that rehabilitation is a key need identified in this rare disorder and should be considered a central part of healthcare delivery for BBS. Due to the obesity problems in BBS, and in particular the higher risk of high blood pressure, diabetes and kidney failure, people with BBS need to have access to assessment of rehabilitation needs. Compared with the general population,[39] adults with BBS had significantly lower levels of physical functioning on objective tests. This indicates that training is an area of need and multidisciplinary care services working jointly with physical therapists could make the difference to better BBS-related outcomes, as addressed in other studies.[16 18]

Second, higher levels of medical healthcare and personal care services (care gets) were significantly and meaningfully correlated with greater difficulty with physical balance (SPPB), self-care and usual activities (EQ-5D-5L). This may indicate that healthcare services were able to meet the individual needs and that the adults with BBS received help for the identified difficulties with physical functioning, self-care and usual activities. Problems with mobility and usual activities (EQ-5D-5L) were reported in just over half of the participants and statistically more often than in the general Norwegian population.[41] However, adults with BBS had less distress (anxiety, depression) compared with the normative data. It may be that adults with BBS have resources to address their mental problems (eg, family members, personal assistant) contributing to less psychological needs, but these were not addressed in our study.

Third, no significant correlation was identified between the most prevalent unmet needs (ie, rehabilitation and social/family support) and the disease-related and self-reported variables (kidney, high blood pressure, BMI, physical functioning, HADS, EQ-5D-5L). For adults with BBS experiencing disease progression (eg, kidney, vision, obesity) and chronicity of the condition, considerable unmet needs are to be expected. Therefore, we speculate that the relationship between health services (gets) and the complexity of BBS is difficult to detect in a small sample. To overcome this limitation, larger studies could help address the unique rehabilitation needs and the unmet health needs in BBS. Given that people with BBS may underestimate the rehabilitation needs, future studies should combine clinical assessments, objective tests and self-reports.

Many of the health issues presented in our study could be addressed in a multidisciplinary team setting by relevant professionals, for example, physicians, physical therapists, social workers, ophthalmologists, dentists, registered dietitians and psychologists; however, none of the participants taking part in this study received such services. A consensus statement study recommended that people with BBS had lifelong follow-ups, treatments for neurological and endocrinological diseases and rehabilitation sessions for visual handicap.[46] The present study builds on earlier studies of rare diseases, showing a need for supportive care in a broad range of domains and unmet needs in primary healthcare.[2 11 47] The BBS-related health problems represent broad types of healthcare needs and require multidisciplinary interventions in addition to pharmacological treatments (eg, blood pressure, diabetes, obesity). Therefore, ensuring the delivery of healthcare and preventative measures to people diagnosed with BBS is important.

BBS lacks pathognomonic signs or symptoms at birth or later, which, combined with a lack of knowledge about BBS, might cause diagnostic delay.[16 48] The age at diagnosis was 9 years in the present study, and the majority of participants had been in contact with educational-psychological services during childhood. Furthermore, 20% of the participants had been referred to child and adolescent mental health services, indicating that children with BBS need treatment for their mental and/or behavioural problems. This finding highlights the importance of early disease intervention. Increased accessibility of genetic testing today may reduce the age at diagnosis compared with when our participants were diagnosed several decades ago.

Only 17% of adults with BBS were employed, which is notably lower than the rate reported in people with various eye diseases (44%) in Norway[49] and lower than the work participation in rare diseases (55%) reported in a recent scoping review.[50] The complexity of BBS makes it difficult to pinpoint the exact reasons for unemployment. Our findings may be limited because the analyses were exploratory and based on a small sample, and further research is needed to evaluate this in more detail. Complex conditions such as BBS with reduced vision, possible cognitive challenges and obesity pose difficulties to the working environment and need to be addressed to improve work participation.

The strengths of this study are the high response rate (68%). Also, this sample of responders appears to be largely representative of adults with BBS in the country (Norway). Evaluations were performed by a multidisciplinary research team, including different healthcare professionals working in hospitals and resource centres for rare conditions in Norway. This study could subsequently contribute to increasing awareness of BBS among professionals working in primary care but also in mental health and specialist health services, where treatments may be administered. No previous study has focused on describing healthcare needs and the provision of and access to healthcare in BBS. Based on present findings, substantial physical and social healthcare needs are currently not addressed, and this study can serve as a starting point for future research on BBS or other rare diseases.

The small sample size may be considered a limitation because it significantly reduces the statistical power. The data were self-reported, which might have resulted in participants underestimating their problems because of a lack of self-awareness or having cognitive difficulties understanding the questions. Because individuals under 16 years of age were excluded, the study has limited generalisability to children. In addition, adults with BBS who did not participate in this study might have other healthcare needs. The cross-sectional

design limits the assessments of longitudinal changes and causal associations between healthcare use (gets) and health outcomes. We have compared our data to normative data. This is for reference only, and caution is needed due to differences in, for example, age distribution, sex, sample size, data collection and other factors.

Conclusions

Adults with BBS were found to have unmet physical, social and medical needs, which may contribute to health concerns. Rehabilitation needs were the greatest unmet needs and require special attention. Difficulties with physical functioning, self-care and usual activities were related to access to health services, indicating that the services were able to meet these needs. Given the complexity and heterogeneity of BBS, effective management requires a multidisciplinary approach that focuses not only on medical follow-up but also on functional mobility and social care to provide optimal personalised care and rehabilitation for all individuals with BBS.

Acknowledgements The research team is deeply grateful to all the individuals with Bardet-Biedl syndrome for their time and investment in taking part in this study. We would like to thank the two representatives of the Norwegian Organisation for Bardet-Biedl syndrome for their involvement: Richard Ødegaard and Lill Susann Lerudsmoen.

Contributors The authors' contributions to the manuscript were as follows: conceptualisation and methodology: all the authors. Formal data analyses and writing of the original draft: CFR and SS. Supervision: SS, CvdL and RB. Review of the manuscript and editing and validation of the final text: all the authors. SS is the guarantor.

Funding This study was supported by grants from Raagholtstiftelsen in Norway (to Solrun Sigurdardottir).

Competing interests SS has received speaker fees from Sanofi. The other authors have no competing interests to declare.

Patient and public involvement Patients and/or the public were involved in the design, conduct, reporting or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study, registered at ClinicalTrials.gov, NCT05400278, involves human participants and was approved by The Norwegian Regional Committee for Medical Research Ethics in Southeast Norway (number 166639) and the Data Protection officer at Oslo University Hospital (number 20/21045) approved the study.[51] Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. Norwegian ethical and legal restrictions prevent the authors from uploading or sharing data with public repositories. Individuals with Bardet-Biedl syndrome in Norway belong to a relatively small group, and very little personal data are needed to indirectly identify individual study participants.

ORCID iDs

Cecilie Fremstad Rustad http://orcid.org/0000-0001-7903-9087
Hilde Nordgarden http://orcid.org/0000-0003-3252-1735
Jeanette Ullmann Ullmann Miller http://orcid.org/0009-0005-8609-9631
Mina Susanne Weedon-Fekjær http://orcid.org/0000-0003-1791-4485
Kristian Tveten http://orcid.org/0000-0003-1316-5843
Charlotte von der Lippe http://orcid.org/0000-0003-3176-0160
Solrun Sigurdardottir http://orcid.org/0000-0002-7194-3570

REFERENCES

1 Austin CP, Cutillo CM, Lau LPL, *et al*. Future of Rare Diseases Research 2017–2027: An IRDiRC Perspective. *Clinical Translational Sci* 2018;11:21–7.
2 Long JC, Best S, Nic Giolla Easpaig B, *et al*. Needs of people with rare diseases that can be supported by electronic resources: a scoping review. *BMJ Open* 2022;12:e060394.
3 Haendel M, Vasilevsky N, Unni D, *et al*. How many rare diseases are there? *Nat Rev Drug Discov* 2020;19:77–8.
4 EUR-lex, access to european union law.document 02000r0141-20190726. consolidated text: regulation (ec) no 141/2000 of the european parliament and of the council of 16 december 1999 on orphan medicinal products. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02000R0141-20190726 [Accessed 1 Aug 2024].
5 Ferreira CR. The burden of rare diseases. *Am J Med Genetics Pt A* 2019;179:885–92.
6 Chung CCY, Hong Kong Genome P, Chu ATW, *et al*. Rare disease emerging as a global public health priority. *Front Public Health* 2022;10:1028545.
7 Evans WR, Rafi I. Rare diseases in general practice: recognising the zebras among the horses. *Br J Gen Pract* 2016;66:550–1.
8 Vandeborne L, van Overbeeke E, Dooms M, *et al*. Information needs of physicians regarding the diagnosis of rare diseases: a questionnaire-based study in Belgium. *Orphanet J Rare Dis* 2019;14:99.
9 Fredwall S, Allum Y, AlSayed M, *et al*. Optimising care and follow-up of adults with achondroplasia. *Orphanet J Rare Dis* 2022;17:318.
10 Groft SC, Posada M, Taruscio D. Progress, challenges and global approaches to rare diseases. *Acta Paediatr* 2021;110:2711–6.
11 Depping MK, Uhlenbusch N, von Kodolitsch Y, *et al*. Supportive care needs of patients with rare chronic diseases: multi-method, cross-sectional study. *Orphanet J Rare Dis* 2021;16:44.
12 Zelihić D, Hjardemaal FR, Lippe C von der. Caring for a child with Bardet-Biedl syndrome: A qualitative study of the parental experiences of daily coping and support. *Eur J Med Genet* 2020;63:S1769-7212(19)30699-8.
13 Pelentsov LJ, Fielder AL, Laws TA, *et al*. The supportive care needs of parents with a child with a rare disease: results of an online survey. *BMC Fam Pract* 2016;17:88.
14 Benito-Lozano J, Arias-Merino G, Gómez-Martínez M, *et al*. Diagnostic Process in Rare Diseases: Determinants Associated with Diagnostic Delay. *Int J Environ Res Public Health* 2022;19:6456.
15 Chandra B, Tung ML, Hsu Y, *et al*. Retinal ciliopathies through the lens of Bardet-Biedl Syndrome: Past, present and future. *Prog Retin Eye Res* 2022;89:S1350-9462(21)00096-3.
16 Forsythe E, Kenny J, Bacchelli C, *et al*. Managing Bardet-Biedl Syndrome-Now and in the Future. *Front Pediatr* 2018;6:23.
17 Forsythe E, Beales PL. Bardet-Biedl syndrome. *Eur J Hum Genet* 2013;21:8–13.
18 Kenny J, Forsythe E, Beales P, *et al*. Toward personalized medicine in Bardet-Biedl syndrome. *Per Med* 2017;14:447–56.
19 Meyer JR, Krentz AD, Berg RL, *et al*. Kidney failure in Bardet-Biedl syndrome. *Clin Genet* 2022;101:429–41.
20 Tomlinson JW. Bardet-Biedl syndrome: A focus on genetics, mechanisms and metabolic dysfunction. *Diabetes Obes Metab* 2024;26 Suppl 2:13–24.
21 Forsythe E, Haws RM, Argente J, *et al*. Quality of life improvements following one year of setmelanotide in children and adult patients with Bardet-Biedl syndrome: phase 3 trial results. *Orphanet J Rare Dis* 2023;18:12.
22 Melluso A, Secondulfo F, Capolongo G, *et al*. Bardet-Biedl Syndrome: Current Perspectives and Clinical Outlook. *Ther Clin Risk Manag* 2023;19:115–32.
23 Denniston AK, Beales PL, Tomlins PJ, *et al*. Evaluation of visual function and needs in adult patients with bardet-biedl syndrome. *Retina (Philadelphia, PA)* 2014;34:2282–9.
24 Panny A, Glurich I, Haws RM, *et al*. Oral and Craniofacial Anomalies of Bardet-Biedl Syndrome: Dental Management in the Context of a Rare Disease. *J Dent Res* 2017;96:1361–9.
25 Smith BB, Barbara DW, Hyder JA, *et al*. Anesthetic considerations for patients with Bardet-Biedl syndrome: a case series and review of the literature. *Paediatr Anaesth* 2016;26:429–37.
26 Pomeroy J, Krentz AD, Richardson JG, *et al*. Bardet-Biedl syndrome: Weight patterns and genetics in a rare obesity syndrome. *Pediatr Obes* 2021;16:e12703.

27 Mujahid S, Hunt KF, Cheah YS, *et al*. The Endocrine and Metabolic Characteristics of a Large Bardet-Biedl Syndrome Clinic Population. *J Clin Endocrinol Metab* 2018;103:1834–41.
28 Keifer E, Berg RL, Richardson JG, *et al*. Early development and adaptive functioning in children with Bardet-Biedl syndrome. *Am J Med Genet A* 2024;194:31–8.
29 Forsythe E, Mallya UG, Yang M, *et al*. Burden of hyperphagia and obesity in Bardet-Biedl syndrome: a multicountry survey. *Orphanet J Rare Dis* 2023;18:182.
30 McColl MA, Shortt S, Gignac M, *et al*. Disentangling the effects of disability and age on health service utilisation. *Disabil Rehabil* 2011;33:1253–61.
31 Moyer VA, Force USPST. Screening for and management of obesity in adults: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med* 2012;157:373–8.
32 Turner-Stokes L, McCrone P, Jackson DM, *et al*. The Needs and Provision Complexity Scale: a multicentre prospective cohort analysis of met and unmet needs and their cost implications for patients with complex neurological disability. *BMJ Open* 2013;3:e002353.
33 van Walsem MR, Howe EI, Iversen K, *et al*. Unmet needs for healthcare and social support services in patients with Huntington's disease: a cross-sectional population-based study. *Orphanet J Rare Dis* 2015;10:124.
34 Forslund MV, Borgen IMH, Karic T, *et al*. Validity of the Norwegian Version of the Needs and Provision Complexity Scale (NPCS) in Patients with Traumatic Brain Injury and Atraumatic Subarachnoid Hemorrhage. *J Clin Med* 2024;13:752.
35 van Walsem MR, Howe EI, Ruud GA, *et al*. Health-related quality of life and unmet healthcare needs in Huntington's disease. *Health Qual Life Outcomes* 2017;15:6.
36 Laurie K, Foster MM, Borg DN, *et al*. Perceived service adequacy and unmet need after discharge from brain injury rehabilitation. *Disabil Rehabil* 2023;45:3252–61.
37 Holmøy AKT, Johannessen CH, Hope S, *et al*. Uncovering health and social care needs among myotonic dystrophy patients: Utility of the Needs and Provisions Complexity Scale. *Acta Neurol Scand* 2019;139:526–32.
38 Guralnik JM, Ferrucci L, Pieper CF, *et al*. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci* 2000;55:M221–31.
39 Bergland A, Strand BH. Norwegian reference values for the Short Physical Performance Battery (SPPB): the Tromsø Study. *BMC Geriatr* 2019;19:216.
40 Nord E. EuroQol: health-related quality of life measurement. Valuations of health states by the general public in Norway. *Health Policy* 1991;18:25–36.
41 Garratt AM, Hansen TM, Augestad LA, *et al*. Norwegian population norms for the EQ-5D-5L: results from a general population survey. *Qual Life Res* 2022;31:517–26.
42 Bjelland I, Dahl AA, Haug TT, *et al*. The validity of the Hospital Anxiety and Depression Scale. *J Psychosom Res* 2002;52:69–77.
43 Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983;67:361–70.
44 Forskningssenter H. HUNT databank. 2025. Available: https://hunt-db.medisin.ntnu.no/hunt-db/#variable/7259
45 Åsvold BO, Langhammer A, Rehn TA, *et al*. Cohort Profile Update: The HUNT Study, Norway. *Int J Epidemiol* 2023;52:e80–91.
46 Dollfus H, Lilien MR, Maffei P, *et al*. Bardet-Biedl syndrome improved diagnosis criteria and management: Inter European Reference Networks consensus statement and recommendations. *Eur J Hum Genet* 2024;32:1347–60.
47 Bogart K, Hemmesch A, Barnes E, *et al*. Healthcare access, satisfaction, and health-related quality of life among children and adults with rare diseases. *Orphanet J Rare Dis* 2022;17:196.
48 Berezovsky A, Rocha DM, Sacai PY, *et al*. Visual acuity and retinal function in patients with Bardet-Biedl syndrome. *Clinics (Sao Paulo)* 2012;67:145–9.
49 Brunes A, Heir T. Visual impairment and employment in Norway. *BMC Public Health* 2022;22:648.
50 Velvin G, Dammann B, Haagensen T, *et al*. Work participation in adults with rare genetic diseases - a scoping review. *BMC Public Health* 2023;23:910.
51 World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* 2013;310:2191–4.