



Studies on blind and visually impaired users in LIS literature: A review of research methods

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ABSTRACT

Current sight-centered designs and services in library and information science (LIS) do not effectively support blind and visually impaired (BVI) users. Simultaneously, there is a lack of studies focused on the research methods utilized in BVI research. This study analyzed 165 research papers retrieved from four LIS databases over a 40-year period. The uniqueness of BVI research methods on research design, data collection, and data analysis is highlighted. While survey and experiment are the two most commonly applied research designs in LIS research, survey and evaluation are the main research designs for BVI research. Concurrently, assessment report is a unique data collection method employed. More quantitative analysis was also applied in BVI research, and most of the qualitative analysis was not specified. This study reveals an opportunity to enhance the diverse approaches to BVI research and further satisfy BVI users' unique needs.

1. Introduction

According to the World Health Organization, blind and visually impaired (BVI) people comprise around 2.2 billion of the world's total population (World Health Organization, 2020). In this study, BVI users are defined as people who have experienced full or partial vision loss and are reliant upon tools such as screen readers to effectively interact with information retrieval (IR) systems. While BVI populations have been studied extensively to find solutions to more general widespread accessibility and usability issues, these users have unique needs, challenges, strategies, and preferences with regards to finding, accessing, and using information in a library and information science (LIS) context. For several decades, there has been a scholarly interest in better understanding and serving diverse, marginalized, and vulnerable populations within the LIS community (Du, Xie, & Waycott, 2020; Sung & Parboteeah, 2017). This includes studies that have been done on people with different types of disabilities and impairments (Berget & MacFarlane, 2020; Hill, 2013).

With the advent of the Internet and a global increase in the use of IR systems and digital technologies over the past two decades, a significant number of research studies have been published within the LIS field on how BVI individuals and groups have utilized online technology to seek and find information, in addition to the various challenges they have encountered (Andronico, Buzzi, Castillo, & Leporini, 2006; Jones, Farris,

Elgin, Anders, & Johnson, 2005; Lazar, Allen, Kleinman, & Malarkey, 2007; Xie, Babu, Castillo, & Han, 2018). Most of these publications have focused on issues of accessibility, in addition to the various library services that have been established to assist this specialized population (Babu & Xie, 2017; Bodaghi, Awang-Ngah, & Abdullah, 2014; Xie et al., 2020). However, a comprehensive review of the BVI literature in the field concentrating on the analysis of the associated research methods for each study has not yet been explored.

2. Problem statement

As stated, BVI users have unique needs, behaviors, and challenges in the information world. However, current IR system designs and library services have not adequately addressed all these issues to date, nor have any publications reviewed the methods that have been applied to examine this population. It is therefore important to conduct a comprehensive examination of relevant publications in the field on the topic to determine what types of methods have already been utilized to assist BVI populations and note any gaps where further research could be done. At present, there is a lack of empirical studies in the LIS field which analyzes the diverse research methods and approaches that have been applied to BVI users and discusses the areas of future development. Research methods are the fundamental component of any study (Peritz, 1980), which involve specific components at different levels, including

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the formulation of a research design, collection of data, and analysis of the findings (Chu & Ke, 2017; Järvelin & Vakkari, 1990). An examination of the various methodologies that have been used in different studies may provide some insight on the current state of scholarly development within a particular research area or discipline (Julien, Pecoskie, & Reed, 2011). Researchers of this study conducted such an analysis and provide recommendations for additional research on BVI topics that will greatly assist scholars, librarians, and information specialists in addressing the ongoing needs and challenges of this population. More specifically, it investigated the different types of research designs, data collection methods, and analysis methods that have been incorporated into existing studies on BVI users over the past four decades by examining publications from 1980 to 2020. It also analyzed the relationships between different BVI topics that have been covered in the literature and the research methods that have been applied.

In conducting an extensive analysis of the literature, this study answered the following research questions:

1. What are the types of BVI-related topics investigated in LIS literature and how have they changed over time?
2. How are the different types of research designs applied to the diverse BVI related topics in LIS literature?
3. How are the different types of data collection methods applied to the diverse BVI related topics in LIS literature?
4. How are the different types of data analysis methods applied to the diverse BVI related topics in LIS literature?

3. Literature review

3.1. Research methods in LIS

There has been a long-standing interest among LIS scholars to investigate the evolution of the discipline including the examination of research methods (Järvelin & Vakkari, 1990; Kumpulainen, 1991). Notably, previous analyses concerning the application of research methods were conducted primarily on journal publications, which have been widely seen as representative of current research.

Research designs function as the overall plan for guiding and implementing specific research procedures (Creswell & Creswell, 2018; Järvelin & Vakkari, 1993). As one of the pioneering studies that examined methodological applications in LIS, Järvelin and Vakkari's (1993) content analysis study indicates that survey was the most frequently applied research design in empirical LIS research that was published in 1965, 1976, and 1985. Concentrating on selected journal literature in 2005, Hider and Pymm (2008) found that survey remained central as a research design, accounting for 30.5% of the sampled publications, followed by experiment (20.8%). Later, Tuomaala, Järvelin, and Vakkari (2014) also reported that survey was the prevailing research design in the field, followed by evaluation and experiment. Recently, a systematic review of publications concerning methods applied in LIS research highlighted the dominance of survey, theoretical analysis, content or protocol analysis, historical analysis, and bibliometric analysis in the field (Ullah & Ameen, 2018).

Under the umbrella of research design, data collection and analysis methods provide specific materials and analytical tools to carry out the research process. Järvelin and Vakkari (1993) found that questionnaires and interviews were the most popular data collection methods used in LIS publications, which has been echoed by later research studies (Hider & Pymm, 2008; Tuomaala et al., 2014). There are generally three main categories of data analysis methods, including qualitative, quantitative, and mixed methods (Johnson, Onwuegbuzie, & Turner, 2007). The proportion of LIS articles using qualitative methods was, and still is, relatively low compared with their quantitative counterparts (Järvelin & Vakkari, 1993; Tuomaala et al., 2014). Quantitative analysis methods

have been widely used by LIS scholars (Malliari & Togia, 2017; Tuomaala et al., 2014; Zhang, Zhao, & Wang, 2016). In particular, descriptive statistics has been mostly employed by LIS researchers for data analysis (Ullah & Ameen, 2018). It is also worth mentioning that despite the strength of mixed methods research (MMR), which integrates qualitative and quantitative methods, MMR accounts only for a small portion of LIS research publications. From 2005 to 2006, for example, out of the 465 articles that were published in four top LIS research journals at that time, only 5% were MMR (Fidel, 2008). The proportion was even lower (less than 0.5%) in the overall LIS literature between 2008 and 2018 (Hayman & Smith, 2020).

3.2. Research methods in user studies

LIS scholars have conducted user studies involving different types of populations, including those considered to be vulnerable, such as older adults, children, people with disabilities, refugees, and immigrants (Du, Xie, & Waycott, 2020; Sung & Parboteeah, 2017). Along with the massive body of user studies in LIS, there have also been widespread discussions concerning method-related issues in user studies.

Multiple research designs have been employed in LIS research, though some of them are used and discussed more frequently than others. Survey and experiment, for example, have historically been the most popular research designs in LIS. An early review of online public access catalog (OPAC) user studies show that survey was the most frequently adopted research design several decades ago (Seymour, 1991). Later, Matusiak (2017) examined the methodological aspects of studies concerning the information behavior of image users and found that experiment and survey were the most used research designs. Studies also show that ethnography has been increasingly used in research done on libraries and library users (Khoo, Rozaklis, & Hall, 2012), particularly in the context of academic libraries (Ramsden, 2016). Moreover, Bamkin, Maynard, and Goulding (2016) examined and confirmed the appropriateness of combining ethnography and grounded theory to research children by providing methodological implications for LIS researchers interested in children-related issues.

In LIS user studies, researchers heavily rely on a limited number of data collection methods, mainly questionnaires, interviews, observation, and transaction logs. According to Julien et al. (2011), questionnaires and interviews were the most employed methods in human information behavior research between 1999 and 2008. Similarly, Matusiak (2017) found that questionnaires, transaction logs, and interviews were the most frequently applied data collection methods in studies that focus on the information behavior of image users. As a nonintrusive approach, transactions logs have also been commonly used by LIS researchers to capture how users interact with different IR systems (Jansen & Pooch, 2001; Matusiak, 2017; Seymour, 1991). Regarding research concerning accessibility and usability, Hill (2013) found that accessibility testing, questionnaires, and interviews were frequently applied to investigate relevant issues.

For data analysis methods, Martzoukou (2005) pointed out that both quantitative and qualitative analysis methods played important roles in understanding human information behavior. Using a content analysis of methodological applications, Vakkari (2008) compared Information Seeking in Context (ISIC) conference papers in 1996 and 2008 and found a growing number of qualitative studies and a declining trend in quantitative studies. However, not all studies generated similar results. For example, focusing on the information behavior of image users, Matusiak (2017) discovered that 65.7% of the sampled studies used quantitative analysis methods, while only 28.6% used qualitative analysis methods.

3.3. BVI studies in LIS

People with different types of impairments or disabilities (e.g., cognitive impairments, sensory impairments, and motor impairments)

comprise an important user group in LIS research (Berget & MacFarlane, 2020). There has been a primary focus on BVI users in LIS in recent decades (Hill, 2013).

BVI research in LIS involves several important areas, including, but not limited to, library services for BVI users, the information behavior of BVI users, and accessible and usable IR system designs for BVI users. Providing accessible library resources and services for BVI users is a widely discussed topic in the field. For example, Smale (1992), in an early study, surveyed university library services for visually impaired students. Manžuch and Macevičiūtė (2016) examined the performance of the Lithuanian Library for the Blind. Understanding BVI users' information needs and behavior is another critical area. According to Sahib, Tombros, and Stockman (2012), the usage of screen readers had an impact on BVI users' information-seeking behavior, and there were significant differences between the behaviors of BVI users and sighted users at different stages of the information-seeking process. It is also worth noting that with the development of more information technologies and IR systems in recent years, there has been a growing interest in the accessibility and usability of emerging IR systems, such as digital libraries (DLs), in BVI research. Xie et al. (2018), for example, examined BVI users' help-seeking situations and the associated factors during BVI users' interaction behavior with DLs. Moreover, they further tested the accessibility and usability of two interfaces after implementing the help features to reduce five critical help-seeking situations that BVI users faced (Xie et al., 2020).

Despite the growing number of LIS studies focusing on BVI users, no research has been conducted to examine the methodological applications in relevant studies, as well as their association with diverse research topics. This study will address these issues.

4. Methodology

4.1. Sampling and data collection

Focusing on publications that discuss BVI users in an LIS context specifically, four prominent databases in the field were selected to search for publications on this topic (Lasić-Lazić, Špiranec, & Ivanjko, 2015). In this paper, LIS context is defined as journal articles that were collected in LIS online databases. The Web of Science, Library and Information Science Source (LISS), Library, Information Science, and Technology Abstracts (LISTA), and Library Literature & Information Science Index (LLIS) were all searched for research articles. In the Web of Science, individual searches were conducted using each of the 89 journals under the category of "Information Science & Library Science" and then the search results were integrated together. The other three databases are already LIS-oriented, by the nature of their scopes.

The same search terms were used in each database to retrieve the initial results on BVI topics, in addition to filtering the results to English language and Academic Journals only. The search was run as one query with multiple search terms, which included: "blind" OR "visually impaired" OR "visually handicapped" OR "visual impairment" OR "visually challenged" OR "visually disabled" OR "visual disability*" OR "visual disorder" OR "low vision" OR "print disability." Other refining criteria included limiting the range of publications to a span of four decades (1980–July 2020).

Publication records and abstracts from the articles found in the initial searches were then exported into a spreadsheet for more detailed study. After all the duplicates and non-article sources were removed, the researchers manually reviewed the title, abstract, and/or full-text of each remaining article, based on the inclusion criteria as follows: 1) articles that focus on BVI related topics and 2) articles which use research methods to address research questions and/or hypotheses. This article screening process is depicted in Fig. 1. After all the reviews concluded, a

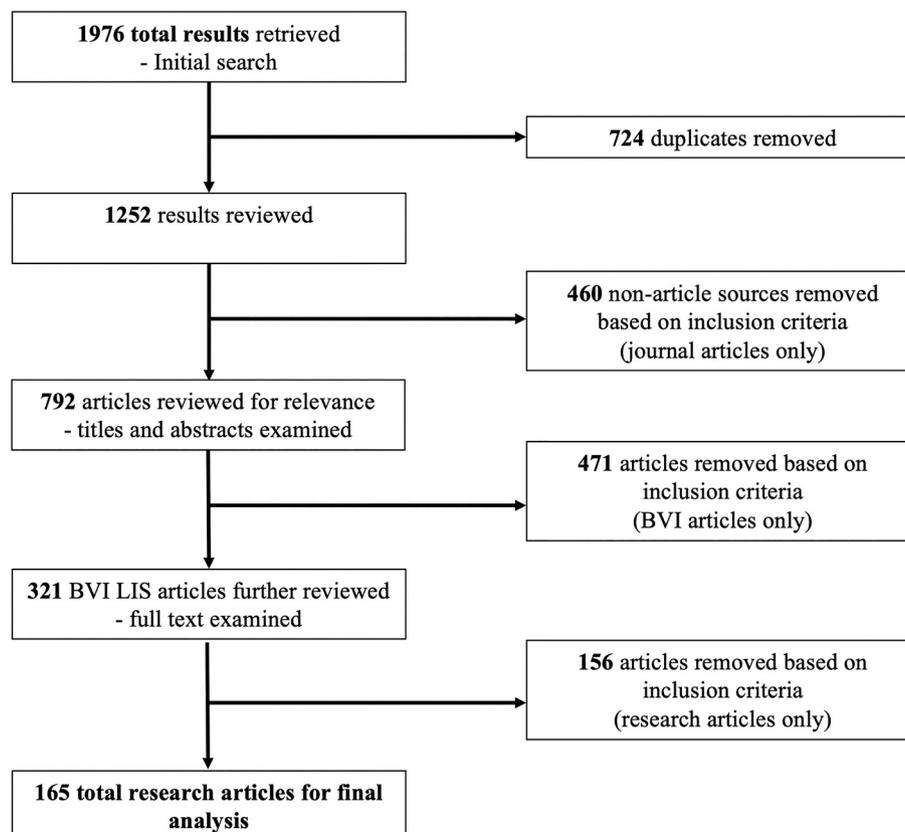


Fig. 1. The article screening process.

total of 165 BVI research publications emerged for this study.

4.2. Data analysis

After the data collection, each full-text publication was systematically reviewed and categorized into one of five main research topics using an open coding process. Open coding is done by attaching concepts to data by labeling, defining, and developing different categories based on the data’s properties (Strauss & Corbin, 1990). Each publication was coded for a main topic, which fell into one of five categories, as shown below in Fig. 2. Two coders participated in the coding process, using Holsti’s method as a formula for calculating the inter-coder reliability (Holsti, 1969). The reliability of the coding process was 0.96. Additionally, the frequency of each topic in the literature was analyzed.

Content analysis was then conducted to analyze the methodological aspects of LIS research concerning BVI users. Content analysis serves as a potent technique for “making replicable and valid inferences from texts” (Krippendorff, 2018, p. 24), which has been widely applied by LIS scholars to examine the literature of interest (Chu, 2015; Hill, 2013; Julien et al., 2011; Matusiak, 2017).

As mentioned, methodological aspects of publications include the research design, data collection methods, and data analysis. Research design is defined as the overarching plans or designs that “provide specific directions for procedures in a research study” (Creswell & Creswell, 2018, p. 48). According to the typology of research designs commonly used in social sciences research, these include quantitative designs (e.g., survey, experiment, and longitudinal design) and qualitative designs (e.g., case study, narrative research, phenomenology, grounded theory, and ethnography) as noted in Creswell and Creswell (2018). Moreover, different from the experiment design, evaluation was also found to be a common research design in this study, which is defined as research involving the application of both qualitative

methods and/or quantitative methods to assess a specific interface, program, system, or service. Data collection methods refer to methods used to gather data for analysis, including questionnaires, interviews, observations, focus groups, transaction logs, and document analysis. Assessment reports are also used to collect data. These are the results created by human subjects, or generated by automatic tools, to check compliance with specific guidelines. While data analysis methods done at the micro level are individual methods that include thematic analysis, open coding, descriptive analysis, t-test, ANOVA, etc., data analysis methods done at the macro level consist of three main types of analysis methods: qualitative analysis, quantitative analysis, and mixed methods analysis.

Each publication was only assigned one BVI research topic, one type of research design, and one type of data analysis method at the macro level. Individual data collection and analysis methods at the micro level were also coded for each publication. If there were multiple collection or analysis methods used in one study, all of them were assigned to that paper. For qualitative studies in which no specific analysis methods were explicitly stated, the term “unspecified qualitative” was assigned as the data analysis method at the micro level.

Based on the coding results, crosstabs were created to show how different types of research designs, data collection methods, and data analysis methods were distributed across BVI topics. A Chi-square test of independence was performed to examine the relationship between types of BVI research topics and types of data analysis methods at the macro level.

5. Results

5.1. BVI topics and associated research design

The results show the types of BVI-related topics in the LIS literature

Topics (Categories)	Definitions	Examples
Accessibility	Assessing the access issues of websites, tools/software, technologies, and systems to support BVI users	Observing how BVI users interact with different web-based interfaces and examining the accessibility challenges they still face
Information Needs and Behaviors	Studying BVI users’ desired needs for information and how they seek information in various contexts	Studying user habits and information-seeking strategies to find and retrieve information in different disciplines
Services	Evaluating the resources, programs, and services provided by libraries to address BVI users’ information needs	Surveying BVI users on which services and resources would better assist them in using the library to find information
Usability	Assessing the ease of learning and using of websites, tools/software, technologies and systems to support BVI users	Testing the usability of interfaces, focusing on ease of use, effectiveness, and user interaction with IR systems
Other	BVI research that cannot be categorized into the above categories	Using social networks to support visually impaired people via a Facebook case study

Fig. 2. The coding scheme of topics.

and how different types of research designs, data collection methods, and data analysis methods are applied to diverse BVI related topics in the field. Out of the 165 empirical research publications retrieved and analyzed over the 40-year period, accessibility has been the most widely published topic on BVI users, with 83 papers written on this subject out of the total examined (Fig. 3). This accounts for half of the publications. Information needs and behavior studies are the second most published topic, with 35 papers. Additionally, there are 29 papers that focus on services, while usability studies are the least published topic with only 16 papers. Finally, there are two papers which fall into the Other category, since they do not meet the criteria specified for the previous four categories.

The publications were analyzed for topic changes over time, from 1980 to 2020. Findings show that only two LIS research publications were written about BVI users during the 1980s, in addition to two publications in the 1990s. These four publications focused only on accessibility and services. By contrast, 44 publications were written about BVI users in the 2000s, and 113 publications in the 2010s. While accessibility remained the dominant topic during all these decades, followed by services for BVI users, more publications have been written on other aspects of BVI user research, such as their information needs and behaviors and usability studies, over the past twenty years. The overall increase in BVI publications over the past two decades can be attributed to more widespread public use of websites, IR systems, and DLs after the 1990s era, and the challenges involved in utilizing these technologies. From January 2020 to July 2020, only four empirical research publications were written about BVI users on accessibility. However, it is still early in the decade, and more studies should emerge in the coming years.

As shown in Table 1 below, survey was the main research design used in publications (31.5%), followed by evaluation design (29.7%), and experiment (16.4%). There were only 11 case studies (6.7%). For the remaining 26 studies, research designs were either not specified or did not belong to those aforementioned (e.g., grounded theory, phenomenological analysis). Survey design was also popular among the sampled studies, possibly due to its flexible nature in reaching out to BVI users. The frequency of applying evaluation and experiment designs is highly associated with the accessibility and usability topic on BVI research.

5.2. BVI topics and associated data collection methods

A wide range of data collection methods were also applied in the studies (Table 2). Questionnaires were the most prevalent data

collection method, accounting for 50.9% of the total publications. This was the most frequently applied data collection method in BVI research on information needs and behavior and services, and the second most popular data collection method for accessibility and usability research. Other frequently applied methods included interviews (42.4%), assessment reports (24.2%), transaction logs (19.4%), and observation (10.9%). Assessment reports do not fall into the other types of data collection methods. Most of these reports (18, 45.0%) were solely based on assessment by human subjects, while 10 (25.0%) were only based on automatic assessment by software, and 12 (30.0%) relied on assessment by both human subjects and software. For example, Riley (2002) manually examined how the interfaces of three database aggregators complied with the Web Content Accessibility Guidelines (WCAG). Yang, Zhao, Liu, and Bielefield (2020) used WAVE and AChecker to evaluate the accessibility of Ivy League library website homepages. To assess the accessibility of Australian national and state/territory library websites, Conway, Brown, Hollier, and Nicholl (2012) conducted a study using expert manual evaluation, assessment of users with disabilities, and an automatic tool called Sortsite. In total, there were 30 studies using assessment reports involving manual evaluation by human subjects, 15 of which recruited BVI users.

More than one half of the included studies (92, 55.8%) used only one data collection method, among which assessment reports (28, 30.4%), questionnaires (26, 28.3%), and interviews (15, 16.3%) were the top three data collection methods. Moreover, 61 (73.5%) of the accessibility papers applied only one data collection method, and assessment reports (28, 45.9%) and questionnaires (12, 19.7%) were the dominant methods among the accessibility publications solely relying on one data collection method. Many studies (73, 44.2%) applied multiple data collection methods, including 47 (28.5%) studies that employed two data collection methods and 26 (15.8%) that used three or more data collection methods. Among the 73 papers involving multiple data collection methods, 22 (30.1%) were accessibility studies, 17 (23.3%) were information needs and behaviors studies, 17 (23.3%) were services studies, 16 (21.9%) were usability studies, and one article (1.4%) was in the "Other" category.

5.3. BVI topics and associated data analysis methods

Table 3 illustrates the distribution of data analysis methods by types of BVI topics. Results show that descriptive statistics were the most frequently applied data analysis method used in 108 (65.5%) of all the sampled studies. Additionally, descriptive statistics topped other analysis methods across all the research topics in terms of frequency, being utilized in 48 (57.8%) of the accessibility studies, 26 (74.3%) of the information needs and behaviors studies, 21 (72.4%) of the services studies, 12 (75.0%) of the usability studies, and one (50.0%) of the studies in the "Other" category. Despite common application of the *t*-test, the use of other inferential statistical methods (e.g., ANOVA, correlation, Chi square, and regression) was limited. Thirty studies (48.8% of qualitative analysis and 37.5% of mixed methods analysis papers) did not indicate which specific qualitative data analysis methods had been applied. Some studies claimed that qualitative data (e.g., interviews) were analyzed qualitatively, but did not explicitly state what specific methods were used, and other studies went directly to the results section without offering descriptions related to data analysis. Thematic analysis and open coding were among the most employed qualitative data analysis methods. Use of a single data analysis method in one study was also prevalent (113, 68.5%), while only 52 (31.5%) incorporated multiple analysis methods. More specifically, 40 studies used two data analysis methods, while 12 studies employed three or more data analysis methods. The "Other" category refers to the collection of data analysis methods used in less than eight studies, including content analysis, regression analysis, and other analysis methods (e.g., verbal protocol analysis, factor analysis, and network analysis). It is also worth noting that the types of data analysis methods utilized in services research were

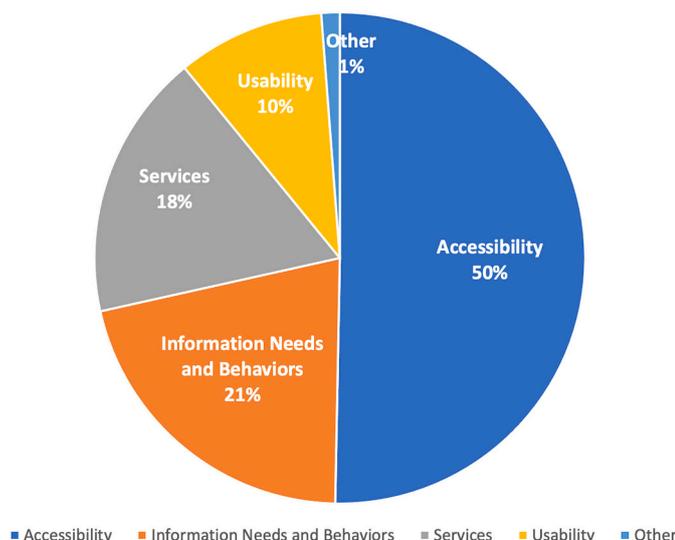


Fig. 3. Distribution of topics.

Table 1
Distribution of research designs by type of BVI related topic.

	Survey	Evaluation	Experiment	Case study	Unspecified / Other	Total
Accessibility	12	41	16	2	12	83
Information needs & behaviors	19	0	3	3	10	35
Services	18	3	0	6	2	29
Usability	3	5	7	0	1	16
Other	0	0	1	0	1	2
Total	52	49	27	11	26	165

Table 2
Distribution of data collection methods by types of BVI related topics.

	Questionnaire	Interview	Assessment reports	Transaction logs	Observation	Think aloud	Document analysis	Focus group
Accessibility	26	21	37	14	3	5	8	0
Information needs & behaviors	26	19	0	8	5	2	0	0
Services	21	19	2	0	3	0	3	5
Usability	10	11	1	9	6	5	0	0
Other	1	0	0	1	1	0	0	0
Total	84	70	40	32	18	12	11	5

Table 3
Distribution of specific data analysis methods by types of BVI related topics.

	Descriptive statistics	Unspecified qualitative	Inferential statistics: t-test	Thematic analysis	Inferential statistics: ANOVA	Inferential statistics: Correlation	Open coding	Inferential statistics: Chi Square	Other
Accessibility	48	18	9	7	5	4	2	2	14
Information needs & behaviors	26	5	3	1	2	3	5	5	9
Services	21	5	0	8	0	0	0	0	0
Usability	12	2	4	0	1	1	1	1	6
Other	1	0	0	0	1	0	0	0	1
Total	108	30	16	16	9	8	8	8	30

less diverse than those used in the studies on other major topics.

A Chi-square test of independence was performed to examine the relationship between types of BVI related topics and types of data analysis methods. As accessibility and usability are closely related, they were placed under the same topic category. Two papers in the “Other” category were not included because of the low number. The results (Table 4) do not show a significant relationship between the types of BVI related topics and the types of data analysis methods, $\chi^2(4, N = 163) = 4.13, p = 0.39$. However, according to Table 5, quantitative analysis was the mostly frequently applied in all three major research topics (i.e., accessibility and usability, information needs & behaviors, and services). Specifically, 59.6% of accessibility and usability research, 60.0% of information needs and behaviors research, and 55.2% of services research relied on quantitative data analysis methods. Qualitative analysis was the second most frequently used analysis type for accessibility and usability studies (29, 29.3%), and for studies on services (8, 27.6%). Mixed-methods analysis was the most uncommon analysis method for research on accessibility and usability (11, 11.11%) and services (5, 17.2%), while it was the second most popular analysis method for information needs and behaviors research (8, 22.9%).

Table 4
Chi square results of data analysis methods by types of BVI related topics.

Research topic	Quantitative (n = 96)	Qualitative (n = 43)	Mixed methods (n = 24)	Statistics
Accessibility and usability	61.5%	67.4%	45.9%	$\chi^2 = 4.13$ $df = 4$ $p > 0.05$
Information needs & behaviors	21.9%	14.0%	33.3%	
Services	16.7%	18.6%	20.8%	

Table 5
Distribution of data analysis methods by types of BVI related topics.

Research topic	Quantitative	Qualitative	Mixed methods	Total
Accessibility and usability	59	29	11	99
Information needs & behaviors	21	6	8	35
Services	16	8	5	29
Other	2	0	0	2
Total	98	43	24	165

6. Discussion

6.1. BVI topics and associated research design

Prior research has identified BVI related topics in LIS that focus on the following areas: library services (Smale, 1992), information needs and behaviors (Manzuch & Maceviciute, 2016), and accessibility and usability studies (Xie et al., 2020). This study further examined the involvement of these topics over the last 40 years. It is worth noting that very few BVI research studies were published in the LIS field in the 1980s and 1990s. While accessibility and usability research started appearing during 2000s and then boomed in 2010s, research on information needs and behaviors and services was mainly distributed in the 2010s. It appears that accessibility and usability issues that BVI users encountered in their interactions with IR systems have been investigated the most by researchers. Compared with non-BVI LIS research, accessibility is the unique topic for investigation because sight-centered design prevents BVI users from accessing some components and features of interface, and the content of visual items of IR systems. The examination of accessibility and usability issues has also led to more research on

information needs and behaviors, and services.

Compared with non-BVI LIS research and user studies, BVI research shows some similarities and differences in the employed research methods ranging from research design, data collection to data analysis. While survey and experiment are the two dominant research designs in LIS research (Hider & Pymm, 2008; Järvelin & Vakkari, 1993; Tuomaala et al., 2014; Ullah & Ameen, 2018) and user studies (Matusiak, 2017; Seymour, 1991), BVI research shows that survey, evaluation, and experiment are the top three research designs.

Survey is the dominant research design in LIS research, but in BVI research, the number for survey design (52) is close to evaluation design (49). Survey design is the top design because questionnaires can be distributed to potential participants with the help of relevant organizations (Bodaghi & Zainab, 2013; Xie et al., 2018). One nuanced distinction between LIS research and BVI research is that BVI survey designs consist of simplified questionnaires that focus on demographic data used in combination with other data collection methods, such as interviews, which are more convenient for BVI participants (Xie et al., 2018). Additionally, survey design in BVI research involves diverse types of stakeholders, such as users, scholars, librarians, and designers (Kumar & Sanaman, 2015; Xie, Babu, Wang, Lee, & Lee, 2021).

Evaluation is the unique research design for BVI research, accounting for about 30% of the publications. The difference is mainly determined by the unique research topics related to BVI research. Accessibility and usability studies constitute the core research areas of BVI research (Berget & MacFarlane, 2020; Xie et al., 2020). Accordingly, evaluation designs that assess the accessibility and usability of systems, websites, software and tools become one of the key research designs. Unlike the preferred experimental approach for usability studies in other types of user studies, these studies were not necessarily carried out in labs via think aloud and log data. They were performed by human subjects or software, with assessment reports as the final products.

This study reveals the following problems and gaps for existing BVI research related to research design. Evaluation designs outperformed experiment designs in accessibility studies. Because of the low incidence of recruiting BVI subjects, it is difficult to satisfy the sampling requirements for experiment designs, related to random sampling and the size of the participant sample (Brulé, Tomlinson, Metatla, Jouffrais, & Serrano, 2020; Oppenheim, 2013; Tigwell, Gorman, & Menzies, 2020). Working with BVI associations at national and local levels is an effective approach to recruit BVI subjects for experiments (Xie et al., 2020). At the same time, research designs can be expanded to longitudinal studies and grounded theory, which are lacking in BVI research. Longitudinal studies can help researchers and practitioners understand the evolution of a specific topic related to BVI research. Simultaneously, more theory-driven research is critical for the enhancement of BVI research. Theories are needed to explain the unique and complexity of BVI users' information needs and behaviors.

6.2. BVI topics and associated data collection methods

The findings in this study for data collection are consistent with previous research (Hider & Pymm, 2008; Järvelin & Vakkari, 1993; Tuomaala et al., 2014), showing that questionnaires and interviews were the main data collection methods used. Compared to prior research, assessment reports are a unique third-most frequently applied data collection method, because accessibility and usability issues are the critical research topics related to BVI users. Among them, about 75% of the studies recruited human subjects (e.g., BVI users, sighted users, and developers/experts) who performed accessibility testing using specific guidelines, such as WCAG, The Americans with Disabilities Act (ADA), the amended Section 508 of the Rehabilitation Act of 1973, self-developed evaluation criteria, etc. The rest (25%) used accessibility evaluation tools, such as WAVE, AChecker, Bobby, WebXACT, and SortSite. While triangulation is applied in less than half of the studies (44.2%), there are still 55.8% that only applied one data collection

method. Even lower was the percentage of studies where multiple data collection methods applied to a specific topic. For example, only 26.5% of the accessibility studies employed more than one data collection method, unlike usability studies in LIS research which employ multiple data collection methods, such as questionnaires, think aloud, transaction logs, and interviews. Assessment reports and questionnaires account for more than half of the studies in accessibility research relying on one data collection method. Without think aloud data and transaction log data, it is difficult for researchers to clearly record and understand BVI users' behaviors and the reasons behind their actions (Xie, Babu, Lee, Wang, & Lee, 2021).

The dominant use of questionnaires reveals the problems with BVI research because questionnaires in general can only offer quick and easy data and it is difficult to capture people's instant thoughts, needs, behaviors, and in-depth views, and feelings on systems and services. Questionnaires should be the essential supplementary data collection method rather than the primary one. Furthermore, it is imperative to incorporate multiple data collection methods. For accessibility and usability studies, think aloud data can offer much richer data than the questionnaire data in relation to participants' thoughts and behaviors. Triangulation is critical to test validity through the merging of information from different sources. Additionally, the accessibility and usability studies should involve more human subjects, especially BVI users.

6.3. BVI topics and associated data analysis methods

In LIS research and user studies, data analysis methods align with the research topics. For example, examining information-seeking users involves more qualitative analysis (Vakkari, 2008), but IR studies, including image user studies, contain more quantitative analysis (Matusiak, 2017). There is a decrease in using qualitative methods and increase in using quantitative methods, based on previous LIS research (Järvelin & Vakkari, 1993; Malliari & Togia, 2017; Tuomaala et al., 2014; Zhang et al., 2016). Data analysis on BVI research follows the same pattern in which more quantitative than qualitative analysis has been performed. However, descriptive analysis constitutes most of the studies, while inferential analysis was applied to only a small number of publications. *t*-test was applied more than other inferential methods, such as ANOVA, correlation, and Chi-square for comparison research. The comparisons are either between or among different types of users, in particular, between BVI users and sighted users, or between or among diverse types of interfaces or systems, although the comparison is still limited as it requires more efforts and high costs. For qualitative analysis, one critical problem is that many qualitative studies in BVI research do not specify their data analysis methods. Qualitative analysis consists of diverse data analysis methods that require researchers to follow specific standards and procedures (American Psychological Association, 2020; O'Brien, Harris, Beckman, Reed, & Cook, 2014). Without specifying qualitative analysis methods, other researchers cannot assess the validity and reliability of these studies. In BVI research, thematic analysis and open coding were the commonly applied qualitative analysis methods, and other types of qualitative methods were either not reported or not frequently used. Furthermore, there is a lack of theory developed based on the studies. Even though importance and relevance of qualitative research and methods have been long acknowledged by LIS scholars (Cibangu, 2013; Fidel, 1993), there is a need to make more theoretical contributions to the academic community. This problem is much more severe with BVI research. Granikov, Hong, Crist, & Pluye (2020) recommend including explicit and transparent descriptions that indicate the research purpose, the priority and sequence of the quantitative and qualitative methods, and the types of integration used in mixed methods studies. This applies to BVI research.

Problems for both qualitative analysis and quantitative analysis were identified from the study. Qualitative publications need to specify their specific data analysis methods, in particular coding techniques need to

be described and justified so readers can understand and assess the derived results. Additionally, researchers can apply the same techniques in another setting and/or for another subject group. Simultaneously, parametric and nonparametric inferential analyses need to be promoted to test the relationships between/among variables and to ensure the generalizability of the research results. Last, mixed methods including both qualitative and quantitative data analysis should be incorporated more into BVI research to portray a comprehensive picture of the BVI users.

6.4. Limitations of the study

This study also has its limitations. Although the sample of this study covers research papers in four main LIS databases, there is still the possibility of missing some BVI related papers that are published in the LIS field. Additionally, there may be some BVI studies that are associated with LIS areas, but not published in LIS journals. Therefore, they are not included in the LIS databases or this study. Publications were also limited to English language only over the last four decades, until July 2020. It does not examine any studies that were published before or after that time period.

7. Conclusion

This is the first study that reviewed BVI research in LIS literature over the last 40 years. BVI users have their own special needs, exhibit unique behaviors, and face diverse challenges. Current sight-centered designs and services do not effectively support BVI users in their interactions with IR systems and library/information services. It is critical for researchers to investigate key BVI issues to support BVI users and satisfy their needs. To ensure the findings of the BVI research valid, reliable, and generalizable, it is imperative to examine the research methods that have been applied in BVI studies. By comparing the results of this study with research methods in LIS and user studies, the findings not only present the distinctive patterns but also reveal problems and gaps related to research design, data collection, and data analysis of BVI research.

Future studies can extend to research on other types of disabilities and further compare their similarities and differences on the research methods employed. Moreover, researchers in this study manually coded all the research methods data. Future research can also analyze the same dataset via text mining and further uncover the strengths and limitations of applying text mining to the research methods analysis of user studies and LIS research.

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Declaration of Competing Interest

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