Challenges faced by the Employed Indian DHH Community

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Abstract. One-sixth of the global Deaf or Hard-of-Hearing (DHH) population resides in India. However, most of the research on the DHH population is situated in the Global North. In this work, we study the accessibility issues faced by the DHH community in India by conducting 15 interviews and surveying 131 people. We focus on the employed DHH community for two reasons: (a) to gauge the effectiveness of the widespread intent to increase diversity, equity, and inclusion in workplaces, and (b) to establish the state of early adoption of (accessible) technology. Our work reveals that our participants face acute communication challenges at the workplace primarily due to non-availability of certified interpreters critically impacting their outcomes at work. We report the consequent workarounds used, including the human infrastructure available to our participants and how at times it impacts their agency and privacy. We identify socio-cultural and linguistic contexts that contribute to our participants' reduced language proficiency both in sign language and English. We also identify that our participants use a variety of technologies, from video conferencing tools to ride hailing apps, and identify their current usability failings. Based on our findings, we recommend several assistive technologies, such as providing access to on-demand interpreters and accessibility improvements for current video conferencing and smartphone telephony apps.

Keywords: Accessibility · Disability · Assistive Technologies · Workplace · Empirical study · Deaf · Hard-of-Hearing

1 Introduction

The Deaf or Hard-of-Hearing (DHH) community constitutes over 5% of the global population [58]. Due to the inaccessible nature of their environments, this community faces a variety of challenges in their everyday lives. Most of the accessibility research works that study these challenges are situated in the Global North. These studies explore the socioeconomic context of the lives of the DHH community, such as the role of family [23], communication challenges in educational institutions [44], and access to healthcare [35]. Other work has explored accessibility issues faced by the employed DHH community especially in the workplace setting—examining communication patterns, career barriers

and difficulties faced by DHH in Australia [60], communication preferences of DHH professionals in supervisory roles in the USA [25], and a literature survey about experiences of stress and fatigue among the members of the DHH community at work in USA, Europe, and Australia [61]. Such studies assume well-resourced settings and explore technological interventions to aid communication between DHH and hearing people, like custom camera setups to recognize sign language [3], use of video relay services to make calls [15], and teletypewriter technology for emergency calls [73].

Many of these solutions and insights do not generalize to a country like India due to the large differences in cultural and economic context, and access to technology. One example of this cultural difference is the nature of Indian Sign Language (ISL). Unlike American or British Sign Language, ISL is not a *single* language. It has a variety of dialects, such as Delhi Sign Language and Bombay Sign Language [26]. This diversity has impeded standardization and makes communication within the Indian DHH community hard. Other factors specific to India include accessibility-related cultural taboos (reported in work on the Indian blind population [36, 38]), limited opportunities for education in mainstream schools [36], and the lack of trained interpreters [40]. Moreover, the Indian DHH population warrants its own study due to its large size—India is home to 63 million DHH people or one-sixth of the global DHH population [28]. Additionally, hearing loss is the second most common disability in India, representing 18.9% of the disabled population [55]. Despite the above, formal studies on the challenges faced and potential technological solutions for the DHH community in India has not received much research attention.

In this work, we seek to address and focus on a part of this gap by asking the research question: *"What are the key communication challenges faced by the working Indian DHH population today?"* We focus on communication as it is a fundamental challenge faced by the DHH community [60, 25]. Additionally, we focus on the employed DHH demography for two reasons. First, it provides an opportunity to gauge the effectiveness of the widespread intent of employers and the government to increase the diversity, equity, and inclusion in workplaces [8]. Second, it establishes the state of early adoption of (accessible) technology given that employed members of the community have more access to such technology given their financial independence. Moreover, employed members have experiences spanning the workplace, home, and commute settings, thus providing richer context for our study. Hence, we focus on the demography of employed DHH and study challenges faced by them at and related to their work.

Towards the above end, we conducted a mixed-methods study of the employed Indian DHH community. Our qualitative study consisted of 15 virtual interviews; our quantitative study consisted of 131 responses to an online form circulated amongst employed members of the DHH community. Our work reveals that our participants face acute communication challenges at the workplace primarily due to non-availability of certified interpreters critically impacting their outcomes at work. We report the consequent workarounds used, including the human infrastructure available to our participants and how at times it impacts

their agency and privacy. For instance, our participants report taking help of colleagues as intermediaries in communicating with their managers, at the risk to their privacy. We identify socio-cultural and linguistic contexts that contribute to our participants' reduced language proficiency both in sign language and English. Specially, we show that cultural taboos around signing and the lack of a national standardized signing system, delays our participants' development of high proficiency in sign language. We also identify that our participants use a variety of technologies, from video conferencing tools to ride hailing apps, and identify their current usability failings. Based on our findings, we recommend several assistive technologies, such as providing access to on-demand interpreters and accessibility improvements for current video conferencing and smartphone telephony apps. We hope that this work invites attention from both the global DHH research community and the accessibility research community in India.

2   Related Work

In this section, we examine existing work in two related areas—reseach on DHH community globally and on accessibility in India.

2.1   Research on challenges faced by the DHH community

The DHH community relies mainly on assistive technology to understand speech. The methods used by the DHH community to communicate with hearing people have been well studied [31, 25], and several workarounds have been identified, such as avoidance, lip reading, optimizing volume of speech, confirming the message, and using simpler words and signs. Simple aids such as exchanging written/text messages can work, but are much slower and thus not effective for sustained conversation [29]. Several technological solutions have been proposed such as video relay services [15], Internet Captioned Telephone Services [14], and Assistive Listening Devices [18].

Specific contexts such as home, workplace and educational settings have been studied. Several studies are specific to the context of education: the experiences of DHH students in educational institutions [44, 56], hearing students' perspectives on the inclusion of DHH students [33, 13], methods to teach and assess DHH students [11, 53], and reading experiences with assistive tools like text simplification [39, 50]. These studies have found that DHH students may not always disclose their needs and often settle for sub-par accommodations [44, 12]. They also dismantle misconceptions that technology can remove all access barriers generalizing across an entire population [44].

Another context that has been well studied is the home. The home sensitively shapes the experiences of DHH children, since more than 90% of deaf children are born to hearing parents [19], who have to make several decisions regarding communication and language choices on behalf of their children. Research on this decision-making [20, 34] reveal that parents view hearing loss in one of two ways: the *sociocultural* view of deafness aligning with the use of sign language,

or the *audiological* view aligning with the use of the family's spoken language. While the efficacy of these choices vary, it is observed that parents often make decisions based on inadequate information [72].

Lastly, several studies chronicle the experiences of the DHH community in the workplace context [61, 54, 60, 25]. Quantitative findings indicate that meetings are the most difficult workplace situations, followed by training activities and work-related social functions [60]. There exist multiple accommodations to address these challenges, such as better lighting and furniture rearrangement to facilitate seeing other people better, access to sign language interpreters, and automatic live captioning during meetings [54]. Apart from these accommodations, certain personal attributes like persistence and self-advocacy skills, as well as the presence of supportive and helpful co-workers are important to facilitate job satisfaction and success for DHH employees [21]. Awareness of the Americans with Disabilities Act (ADA)[4] [69] among employers, and the perspective of hearing managers of Deaf workers [70] have also been studied.

2.2   Accessibility Research in India

There is limited work on the DHH community in India. Existing work has primarily focused on educating DHH children [55, 74], methodologies to teach English to DHH students [24, 59], and teachers' perspectives on the education of DHH children [57]. We did not find any existing research that studies the broader set of challenges faced by the employed DHH community in India. In the wider space of accessibility research, significant work has been done over the past decade on the visually impaired community in India. This body of research has studied various aspects of the life of people with vision impairment, such as navigation [43, 42], education [38, 37], technology adoption [45], and has proposed accessible solutions [71, 62]. Beyond the visually impaired community, there has also been research on developmental disabilities such as autism [64, 1], cerebral palsy [66], and speech and motor impairment [17].

More recently, researchers have studied the Indian Sign Language (ISL) [68, 67]. These studies focus on the diversity of ISL and its unique characteristics that differ from other sign languages as well as the many spoken languages of India. They examine the several regional dialects of ISL used across India [26], and its high iconicity and use of compound signs [22]. Another crucial feature of ISL that has been examined is its variation across class [22]. Members of the educated middle-class DHH community use a unified and relatively standardized sign language, while the rural DHH have no exposure to this urban form. Instead, the rural DHH community use organically evolved *home-sign systems* [63], specialized to the socio-linguistic context of their communities. To further research on ISL and promote its standardisation and usage, the Government of India established the ISL Research and Training Centre in 2015. Moreover, as part of a

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[4] ADA is a comprehensive civil rights law in USA prohibiting discrimination based on disability in employment, state and local government programs, public accommodations, commercial facilities, transportation and telecommunications.

new National Education Policy announced in July 2021, the Indian government launched an ISL dictionary of 10,000 words and suggested introducing ISL in the school curriculum to improve accessibility and create awareness [46].

In summary, most of the work on challenges faced and solutions adopted by the DHH community in the contexts of education, home, and workplace are situated in the Global North. These do not directly generalize to a country like in India with vast differences in both the socio-economic context and the nature and diversity of the adopted sign language. Accessibility research in India is also limited, with a primary focus on visually impaired, and more recent work on datasets for Indian Sign Language. Given this background, our work focuses on the challenges faced, workarounds employed, and their effectiveness for DHH community in India for the specific context of workplace.

3   Method

To understand the communication challenges faced by the employed DHH community in India, we circulated an online survey amongst employed DHH, followed by semi-structured video interviews. Both the survey and the interviews contained questions about accessibility issues faced in a workplace setting by this demography. The study was approved by the Institutional Review Board at Indian Institute of Technology, Madras. In this section, we present our survey and interview methodologies, along with our data collection and analysis techniques.

3.1   Survey

Our survey consisted of 18 questions—12 multiple-choice questions and 6 open-ended questions—and was administered via Google Forms. The survey was organised in two sections. The first section consisted of demography questions (such as gender, age, occupation, and level of hearing disability). The second section focused on the workplace context (such as *"Does your workplace have a sign language interpreter?"*, *"How often do you have meetings at work?"*, and *"How do you communicate with your coworkers?"*). The final, optional question asked survey participants to provide their email and phone number if they wanted to participate in a follow-up interview. No Personally Identifiable Information was collected unless the participants volunteered to participate in the interviews.

The survey was administered in English. All the survey questions were short, simple, and unambiguous to make them accessible to participants with low English proficiency. The survey was piloted with two researchers and a certified ISL interpreter who provided feedback on question framing. At the start of the survey, its purpose was explained in English and ISL. The survey form was distributed by a certified ISL interpreter, an NGO working for the DHH community, and a philanthropic organization supporting work on the Deaf, within their networks using WhatsApp and email. Furthermore, we asked the survey participants to share the survey within their WhatsApp groups. In order to

be included in the survey, participants needed to be Deaf or Hard-of-Hearing, currently living in India, and employed (either currently or in the recent past).

In total, we received 131 valid responses (107 male, 24 female, age=27.9±5.9 years) over 30 days spanning Jan–Feb 2022. All the survey respondents self-attested as DHH, out of which 42.2% of respondents have profound hearing loss (*i.e.*, complete deafness), 25.9% have moderate hearing loss, and 31.9% have mild hearing loss. Our participants were educated, with 24.4% having Master's degrees, 49.6% having Bachelor's degrees, and the rest having a high school diploma. At the time of answering the survey, due to the COVID-19 pandemic, 65.8% of survey participants worked from home, 22.2% worked solely from the office, and 12.0% worked in a hybrid model.

3.2   Interview

We conducted semi-structured interviews after the survey during Feb–Aug 2022 period. Interview participants were recruited from two sources—survey participants who volunteered to participate in the interview, and recruitment messages shared by a certified ISL interpreter within her network using WhatsApp and email. In the interviews, we asked participants about their sign language education, how they communicate with hearing people (coworkers, managers, and other work related personnel), and accessibility challenges, workarounds and the role of technology in various work settings (like workplace and commute). We also asked them to recall a recent accessibility-related incident and their approach to handle that situation. At the end of the interview, participants were invited to share open comments and express any concerns.

All interviews were conducted remotely by the first two authors using the Google Meet video conferencing tool in the presence of a certified ISL interpreter (female, 27 years old). All the calls were video-recorded with the consent of the participants. Participants were informed that the data would only be used for research purposes. The interviews lasted 30–75 minutes. The authors and the ISL interpreter interacted in English, while the ISL interpreter and the participant communicated in ISL. The interviews were transcribed soon after they were conducted, and we use the exact translation provided by the interpreter when quoting participants. Participants were paid 500 INR for participation.

In total, we interviewed 15 participants (8 male, 7 female, age=21–34 years). Only one participant was currently unemployed, but was employed in the last 6 months. The interview participant demographics are available in Table 1.

3.3   Data Analysis

We conducted a mixed-methods analysis to systematically analyze the collected data: quantitative analysis of surveys and grounded theory analysis of interviews. We subjected our interview data to open coding and rigorously categorized our codes to examine communication challenges, workarounds and the role of technology by the employed DHHs in India. All authors regularly participated in the coding process and iterated upon the codes until consensus was reached.

Over the course of analysis, they interacted over multiple days to: (1) discuss coding plans, (2) develop preliminary codebook, (3) review the codebook and refine/edit codes, and (4) finalize categories and themes. The first-level codes were specific, such as "communication with coworkers", "lip-reading", and "sign language proficiency". After several rounds of iteration, the codes were condensed into high-level themes, such as "ISL education" and "workplace-related challenges". Please note that we refer to survey respondents as 'respondents' and interview participants as 'participants' in the rest of the paper.

Table 1. Demographic details of the interview participants

ID	Age	Sex	Hearing Loss	Location	Education	Sector	Occupation
P1	26	M	Mild	Hyderabad	Bachelor's	IT/BPO	Movie editor
P2	26	F	Moderate	Coimbatore	Bachelor's	IT/BPO	Security Guard
P3	37	M	Moderate	Bombay	High School	Education	Teacher
P4	34	M	Moderate	Hyderabad	Bachelor's	IT/BPO	Expenditure Auditor
P5	25	M	Profound	Theni	Master's	Retail	Data Entry Operator
P6	25	M	Profound	Coimbatore	Bachelor's	E-commerce	Warehouse Assistant
P7	29	M	Profound	Coimbatore	Master's	IT/BPO	Process Executive
P8	21	F	Profound	Hyderabad	Bachelor's	NGO	Video Creator
P9	25	F	Profound	Hyderabad	Master's	IT/BPO	Customer Support
P10	24	F	Profound	Hyderabad	Bachelor's	IT/BPO	Expenditure Auditor
P11	32	F	Profound	Delhi	Bachelor's	Education	Teacher
P12	33	F	Profound	Hyderabad	Bachelor's	IT/BPO	Expenditure Auditor
P13	26	M	Moderate	Trivandrum	Bachelor's	Education	Teacher
P14	25	M	Moderate	Trivandrum	Bachelor's	IT/BPO	Software Developer
P15	21	F	Profound	Hyderabad	Bachelor's	NA	Unemployed

4 Findings

In this section, we discuss findings from our survey and interviews. We first describe various accessibility challenges faced by the employed DHH community in the workplace. Along with challenges, we also present workarounds and the role of technology. Moreover, we provide insights from our study that might explain the core reasons behind the identified challenges.

4.1 Work-related Challenges and Workarounds

We asked survey respondents—"*Where do you find it difficult to communicate with hearing people? (Select all that apply)*" The results show that most respondents (53.4%) experience communication challenges at work, followed by home (38.9%), hospital (36.6%), and commute (29.0%).

Job Descriptions. Our survey respondents were working at 53 different organizations, which we mapped to 12 sectors. We found that the IT-BPO (Information Technology-Business Process Outsourcing) and Finance sectors are the most common sectors employing 38.6% and 15.9% of our survey respondents, respectively. Our interview participants worked in 6 of these sectors, with a majority of them (8) working in the IT-BPO sector. Respondents of the IT-BPO sector mainly worked in roles such as software engineers (13.7%), expense auditors (13.0%), and data entry operators (6.1%). P4 described his job as an expense auditor in an IT-BPO organization:

> "There is an app called Concur. We approve bills there. Bills come from third party, and we see if the amount being claimed matches the amount on the bill. If the amount is not matching, we have to manually delete it and enter the amount printed on the bill. Then we get to the next bill... We have to check each bill within 10 seconds, otherwise our reports per hour goes down. We have to reach [at least] 97% of the weekly target... We have to login for 8 hours per day with an hour of break." – *P4*

We found such job descriptions to be typical. They were designed to minimise communication with other colleagues and/or customers, and required minimal English literacy. In spite of being a white-collar technical job, it was menial requiring minimal (technology) expertise. Moreover, we found 99.2% of survey respondents and all our interview participants worked in individual contributor roles, mainly because such roles require "*no communication with colleagues*". P6 stated that he was "*unable to grow*" in leadership roles in his organization due to communication challenges. As an exception, P8 did not face communication challenges in her workplace, as she worked for a DHH-focused NGO.

Lastly, despite already having a Bachelor's degree, 10 interview participants had to complete additional training courses—like English writing, typing on keyboard, using Microsoft Excel, and video editing—to get employed. Our participants found these courses to be valuable, as "*it taught* [them] *the in-demand skills*" and connected them with prospective employers, thus significantly increasing their likelihood of getting employed.

Access to Interpreters. 49.6% of survey respondents had access to interpreters at work, while another 8.5% had interpreters present only during major events. The rest of them (41.9%) did not have access to any interpreter at their respective workplaces. In contrast, 76.3% of survey respondents used sign language at work, indicating that sign language is used even without interpreters at the workplace. Six of our interview participants stated that their office lacked an interpreter, but four of them still used ISL at their workplace. This was made possible using interesting workarounds, such as:

> "We don't have any interpreter. Initially we faced difficulty in talking to the supervisor but later we started teaching them sign language. We started with alphabets and a few words. Now they can sign!" – *P2*

We also found our participants attending meetings over teleconferencing platforms (like Teams, Zoom) even when they were physically present in their workplace, in order to use the live caption feature offered by these platforms. However, that limited their participation to passive consumer of the ongoing discussion rather than actively participating in it. Still our participants found that to be "*better than being uninformed*".

Meetings. Meetings are a crucial component of office life, with employees across organizations attending meetings for an average 6 hours/week [52]. 30.2% of our survey respondents reported having meetings everyday, with another 34.1% having meetings at least once a week, 16.7% having 1-2 meetings per month, and 19.0% having no meetings. Among our interview participants, these meetings mainly comprised of daily/biweekly work assignments, weekly performance discussions, and monthly training for future assignments. When asked the question "*Are you able to actively participate in meetings?*", 53.7% of survey respondents responded with 'yes', 24.8% responded 'sometimes', and the rest 21.5% stated 'no'. To understand these challenges better, we asked our interview participants about their meetings-related communication experiences.

We found participants with access to interpreters at workplace successfully participated in meetings. In the organizations of P4, P10 and P12, the interpreter jointly leads the team with another manager. That way the interpreter has both work context and is comfortable with ISL. In case of P9's organization, the interpreter does not have a management role; the interpreter conducts a separate follow-up meeting with the DHH employees after a meeting concludes, to "*reiterate everything that was discussed*". Among participants who did not have access to interpreters, P5 reported that he "*mostly skips meetings*" and relies on meeting minutes prepared by the team leader. While such workarounds allowed DHH participants to be updated, it precluded them from meaningfully contributing to such discussions.

A few participants use lip reading to follow meeting discussions. For instance, P7, who learned lip reading and received speech therapy during his childhood, can 'listen' and respond to others, as conversations happen during a meeting. However, this approach could get frustrating, as P7 described:

> "I cannot lipread when others are speaking fast... I can't tell them to slow down. If someone is talking to me fast and I am unable to understand then I ask someone else to explain what that person is saying. The person usually summarizes it instead of telling me the whole story and treats me like a baby... I don't like that... I sometimes turn off my video and sit because I don't understand what people are saying." – *P7*

Five participants mentioned using the auto-generated captions feature offered by video conferencing platforms. While they found the feature useful, they stated two reasons that obstructed their usage of live captions. First, participants struggled to read and understand captions when someone spoke fast: "*If a person is speaking too fast... only 50% of the caption I can read, rest of it I*

miss." (P1). Second, the caption generator often make errors in understanding Indian accents and pronunciations, especially for Indian names.

Conversations with managers. Communication with one's manager is vital to success at work. Participants preferred organizations with interpreters acting as the team lead for DHH employees. Although a few such participants had another hearing reporting manager, their single point of contact was still the (team lead) interpreter, who resolved their doubts and raised concerns with the reporting manager, acting as the intermediary between the DHH employee and his/her reporting manager. In workplaces without interpreters, communication between DHH employees and hearing managers is challenging. The default mode of communication in such cases is written messages, on a piece of paper or over email/WhatsApp. While written messages enable limited communication, it has two drawbacks. First, it is slow and becomes impractical for long, two-way conversations. Second, participants were concerned that writing about an issue "*appears excessively formal*" and may be taken out of context as a complaint. For example, P6 described his hesitation with writing an email requesting promotion:

> "Initially, my [DHH] seniors helped me understand and do my current work. Now I want to go to the next level... I don't like doing the same work for a long time. But [my] manager is not able to understand what I'm trying to say. If I have to write and ask about the promotion, they [the management team] will be asking questions... I am afraid that they will give me lecture on it, so its better to not talk about it." – *P6*

Two participants stated that they took the help of their hearing colleagues often to communicate with their manager. They were more comfortable in having a long written exchange with their colleagues, as the colleagues were not as busy as their managers. E.g., P14, who is the sole deaf engineer in his organization:

> "When I need to have some conversation with my manager, I will first talk to a coworker. Then he/she will come with me to explain to the manager. I used to write [on paper] and explain to coworker for long conversations. Now I use WhatsApp to communicate [with the coworker]... Conversations are usually about work-related issues... I have never discussed my salary with my manager." – *P14*

This apprehension of discussing salary and other private matters may be because the co-worker will become privy to the DHH employee private information.

Other participants (like P6) reported having very limited conversations with their managers. P6 works at an e-commerce warehouse that does not employ an interpreter. His job is to pack products into boxes before they get shipped to customers. Due to his blue-collar work profile, he finds it difficult to communicate even over WhatsApp/email.

> "Before I joined, there were Deaf people working already. They taught the manager some sign language, but not much. I cannot talk about my job role to my manager. I can only say hi/bye to him. He [my manager] only understands conversations like 'did you have your tea?'." – *P6*

Conversations with colleagues. All participants reported that the frequency and quality of interactions with their hearing colleagues were poor. For instance, "*I have only hearing colleagues at work. Conversations with them won't go beyond simple greetings like 'Hi', 'Bye', etc.*" (P14). Such interactions happen using simple, intuitive signs that hearing colleagues can understand without any sign language training/knowledge. Even offices with interpreters, access to interpreters was limited to meetings. Interpreters were not available for informal, unscheduled water-cooler conversations. This resulted in minimal social interaction for the DHH employees.

Results to the survey question, "*How do you communicate with your colleagues at work?*", show that WhatsApp (81.7%) is the most common app used to communicate with colleagues, followed by email (66.4%) and various video conferencing tools, such as Zoom (48.1%), Microsoft Teams (25.2%) and Google Meet (23.7%). While Zoom is the most commonly used video conferencing tool among our survey respondents, this may only reflect their organization's adoption of specific tools and not necessarily the accessibility of these tools. Coincidentally however, our interview participants preferred Zoom (even in offices using Teams/Meet), as Zoom allows a user to quickly shift between participant video tiles on a call (even on a mobile device), thus enabling DHH users to focus on the person speaking or signing. Google Meet on the other hand, automatically identifies the speaker and prominently displays the speaker's video on the user's screen by default, which our participants found "*unusable, as an interpreter was also on the call*". This was also reported as a challenge when viewing shared content such as slide decks which also occupy majority of the screen real-estate by default. Finally, this accessibility challenge also manifests in recordings of meetings where the content recorded depends on automatic choices made by the tool which are not necessarily informed by DHH accessibility.

Transportation. Our participants use three modes of transportation for their daily commute—cabs, auto-rickshaws, and public buses. Ride-hailing cab drivers call their passengers for (a) *confirmatory calls*: informing the service requester that they have arrived at their doorstep, and (b) *query calls*: asking for guidance to reach the exact address of the service requester. Addresses in India are not well-defined, hence such query calls are not uncommon [5]. Our participants never make audio calls. However, they frequently receive confirmatory and query audio calls from ride-hailing drivers (e.g., Uber, Ola) and food delivery personnel (e.g., Swiggy, Zomato). Such calls cause distress to our participants as they can neither understand nor reply to the callers.

> "When I book a cab, it is difficult to guide the person to my place... If I go to the doctor for fever or any problem, I can at least write and show them. But with drivers, there is no way to make them understand. Sometimes I text, but they don't reply and keep calling." – *P9*

All our participants have experienced their rides being cancelled by the driver when they did not pick up the driver's phone calls. Attempts by our participants

to interact with them over text messages were mostly unsuccessful, as drivers were usually driving when our participants messaged, and hence were unable to check and reply to messages. This inability to communicate with cab drivers emerged as a major challenge, with 9 participants complaining about it. The most common workaround (reported by five participants) was to take the help of a family member, nearby hearing neighbour or work colleague to interact with the driver. P4 stated another workaround, wherein his organization provides a free cab pick-up and drop service at a fixed time for its DHH employees. If the employee does not show up on time for his/her pickup, the driver calls the office interpreter and the interpreter checks with the DHH employee.

Despite the phone call related challenges, our participants preferred app-based ride-hailing services over hailing auto-rickshaws on the road: "*It is still much easier to book a cab on the app than to catch an auto [-rickshaw] on the road as it is difficult to explain the destination to auto drivers. In ride-hailing apps, it is easy to put the office address in text.*" (P1). Moreover, due to language differences between auto-rickshaw drivers and our participants, written message-based communication may not be feasible.

Lastly, our participants face unique challenges while using public buses. Public buses are the most affordable means of transportation in India and hence tend to be overcrowded. Moreover, the rider needs to know the correct bus stop to get down at, and the name of the next stop is usually announced by the bus conductor. Thus, a bus ride requires communication with the bus conductor or co-passengers, which is difficult using written messages, both due to the crowd and language differences between co-passengers and our participants. E.g.:

> "While travelling in the bus when I ask 'Which place is this?', they [co-passengers] cannot understand and sometimes ignore me. When I write and ask them, people don't understand English because they are from village. At times, writing in Tamil works." – *P7*

However for office commute, as the source and destination are fixed, public buses provide the most frictionless travel experience for the DHH community.

4.2   Insights into Indian Sign Language

In this subsection, we present findings about ISL that we learnt over the course of our study. Specifically, we examine the state of sign language education in India, the influence of ISL on the way the DHH community perceives English, and the difficulties in communication due to the diversity of ISL.

Sign Language Education. A majority of our participants (11) attended schools for DHH children; the remaining 4 participants attended mainstream schools and struggled throughout. Participants attended mainstream schools mainly because their parents did not want them to be seen as "*different*". They recalled that they were given a hearing aid at school and asked to sit in the front, in an attempt to ensure that they could hear and lipread the teachers.

> "I studied with other hearing students near my house. I went to NISH
> [National Institute of Speech and Hearing] for college where I learnt sign
> language. It was difficult for me while studying in school. I sat in the
> first row. I used hearing aids and could understand slightly. Sometimes
> I could not understand some words and kept asking the teacher... If it
> gets cold like in the winter season, then my hearing reduces and I could
> not hear anything at all, and relied completely on lip reading." – *P14*

This approach resulted in negative experiences—P2 and P12 also mentioned not
able to understand their teachers and relied solely on notes written by their
friends, while P14 complained of social isolation in school due to his disability.

Interestingly, even participants who attended schools for DHH children were
forbidden to use sign language at school, and students were encouraged to lipread
and speak instead. P10 mentioned:

> "I can read lips a little now, but I mostly use ISL. I don't speak at all
> now... When I was a child, the teacher used to teach me and force me to
> speak. I went to a deaf school where there was a speech therapist, but I
> could not understand him." – *P10*

A key finding from our survey results is that this encouragement to speak is
widely prevalent in India, as 49.6% of our survey respondents responded 'yes'
to the question *"Have you had speech therapy?"*. P4 shared that he was encour-
aged to *"practice speaking slowly and clearly"* by his parents and teachers, as
they feared that he would be socially isolated if he relied only on sign language.
Despite this, there was an overwhelming consensus amongst our interview par-
ticipants that they preferred and were comfortable using ISL over speech.

Five of our participants did not learn ISL at home or school, but picked it
up informally from peers, by watching YouTube videos, or through apps like the
DEF-ISL app[5]. Interview participants stated that they found peer learning to
be the most effective way to learn ISL. Three participants mentioned clearing
doubts by asking their friends, and stated, *"practising with friends gave the
confidence needed to use sign language in public"*. All our participants later
learnt ISL formally, either in college as part of their undergraduate studies or
by completing a sign language diploma course.

English literacy. As mentioned earlier, using ISL to communicate with the
hearing community is often not feasible due to the lack of interpreters. Moreover,
these interpreters are very expensive (costing 13–20 USD/hour). Thus, written
English becomes the dominant method to communicate with the hearing people.
However, we found our participants to face various challenges in reading and
writing English, due to a variety of reasons—learning deficit in schools due to late
diagnosis of deafness and social stigma, and linguistic differences between ISL
and English. Below are a few examples of the unique sentence structure used by
our participants, provided by our interpreter from her WhatsApp conversations
with them:

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[5] https://play.google.com/store/apps/details?id=in.eightfolds.deafenabled

"I go start my exercise walking now it" instead of "I shall now start my walking exercise".

"Hard exercise some same gym" instead of "I do some hard exercise in the same gym".

"Before I wash shirt and jeans" instead of "I washed my shirt and jeans before this".

The most apparent difference between ISL and English is the underlying sentence structure. While English follows the SVO (subject - verb - object) order for arranging words in a sentence, ISL follows the SOV (subject - object - verb) order [67]. Due to this, the DHH community tends to follow the SOV order even while communicating in English, resulting in sentences that are confusing to read for non-ISL users. The other major difference between ISL and English is the absence of articles (like 'a' or 'the') and connectives (like 'and' or 'or') in ISL [4]. This results in missing articles/connectives when DHH people write in English too. Finally, P13 (a teacher) noted that DHH students often have difficulty in understanding idioms such as "*time flies*".

Diversity of ISL. ISL is not a single, standardised sign language. Variations in ISL became a frequent topic of conversation during our interviews as our interpreter (who is from Hyderabad) would sometimes fail to understand signs used by our participants who were from different parts of India. For instance:

"The sign for 'marriage' is shown by a mangalsutra (an auspicious necklace used in Hindu weddings) *[performs a sign that draws out a necklace]* in Chennai, while in Hyderabad it is shown by the holding of hands *[performs a sign by touching right hand with left]*, just like how the bride and groom hold hands during weddings..." – *Interpreter*

We observed that these variations in sign language are reflective of India's cultural and linguistic diversity. India comprises of 29 culturally-diverse states and is home to 184 languages (spoken by more than 10,000 speakers). ISL, just like spoken languages, is strongly influenced by the culture of its signers. Three participants mentioned knowing multiple signs for a given word, as they had grown up in multiple cities. P9 stated that even signs for basic words like the days of the week varied across different regions she grew up in.

Participants reported instances where these variations in ISL caused problems during lectures, training workshops, and workplace meetings.

"Sometimes she [my manager at work who knows sign language] will stop and say 'I can't understand what you are signing.' She'll ask me twice or thrice again. She won't understand as she is from North [India]. Sometimes I get fed up and just text her to explain." – *P1*

Apart from the ISL diversity, four participants (from tier-1 cities like Delhi and Mumbai) reported mixing of American Sign Language (ASL) with ISL. This phenomenon is similar to code-switching, wherein a speaker alternates between

two or more languages in the same conversation or utterance [2]. In particular, we found the ISL-ASL switch similar to the Hindi-English switch (called *Hinglish*), which is commonly observed among Hindi-speaking Indians [49]. Our participants specified that the reason for code-switching is the unique advantage offered by ASL. Unlike the two-handed ISL, all ASL alphabets can be signed using one hand [16], thus enabling them to sign while holding objects with their other hand. All the four participants mentioned using ASL mainly for WhatsApp video calls as they could hold their phone with one hand and use the other hand for signing. However, all of them reported that they were not fluent in ASL, and could only fingerspell the alphabets in ASL and know of a few basic ASL signs. Other participants who did not use ASL would sign by using their body or face as a substitute for one hand while holding objects.

5   Discussion

Here, we examine key findings in the broader context of existing work and provide design recommendations.

Comparison to Global North. Most of our participants were employed in the technology sector as (semi) skilled workers with the interpreters often as their reporting managers. Conversely, the DHH community in the Global North were predominantly employed in the manufacturing sector as unskilled workers [27]. A significant distinction in the workplace communication is the varying availability and role of interpreters. In India, we found an acute shortage of interpreters and notably interpreters often doubled up as managers and supported DHH employees with other activities such as cab booking. This provided crucial human infrastructure for the DHH employees. In more rewarding roles (such as software development), managerial roles may require specialized skills perhaps precluding their combination with interpreter roles. In contrast, interpreters are more accessible in Global North [25, 61] and their roles were specialized and did not intersect with managerial responsibilities, leading to distinctly different power structures. There were also major concerns raised around privacy with an interpreter in the Global North [48] or of agency with intermediary hearing colleagues. Consistent with our findings, studies conducted in the Global North indicate that DHH employees face challenges in actively participating in meetings and have limited social interaction with coworkers [25, 60, 61], with a few hearing supervisors learning sign language [32].

In contexts outside work, a notable finding in India was the need for DHH to rely on hearing friends and family to use services for food delivery and commute, as service providers often call to confirm availability and for directions. In contrast, such services are usually contact-less in the Global North reducing dependence of DHH individuals on people around them. In terms of the sign language, a particular challenge in India is the relatively nascent stage of standardization with many local and even home signs in active usage impeding learning and interoperability, in contrast to relatively standardized languages such as ASL.

Interestingly, our participants engaged in code-mixing, incorporating ASL signs within their ISL communication.

Human Infrastructure and Agency. Our participants relied on support from their family, friends, co-passengers, colleagues, interpreters, and even strangers, for their communication needs. Human infrastructuring played a crucial role. In the workplace setting, interpreters played several roles such as being a reporting manager, signing during meetings and important discussions, and also communicating with service providers such as cab drivers for office pick-up. However, our participants reported a challenge in discussing complex matters due to limited knowledge of sign language amongst colleagues. Another challenge was privacy in critical conversations such as discussing salary hike with a manager at work. Such privacy concerns have been raised in prior works as well [48, 25].

Agency and social stigma often conflicted in the choices exercised by guardians of DHH individuals. For instance, our participants were encouraged by their parents and teachers from early childhood to speak, lipread, use hearing aids, and undertake speech therapy to avoid signing in public given the stigma associated with it. These methods were prevalent in both mainstream schools and schools for DHH children. While such approaches worked with moderate success for hard-of-hearing children, the deaf children struggled to communicate throughout. Thus, well-meaning efforts by members of the hearing community to increase the agency of DHH individuals actually have the opposite effect. The role of such stigma has previously reported for the Indian blind population [36]: Parents did not provide white canes to their children with vision impairments to make their children 'look less blind' [36], which curtailed their children's physical and mental growth. This suggests that social stigma supersedes agency in India and serves as an additional hurdle for people with disabilities.

Role of Technology. Technology plays a crucial and multi-dimensional role in the lives of our DHH participants. Many of our participants are employed in the technology sector and work on computers (as data entry operators, expense auditors, and software engineers). The IT sector has a major footprint in India: It contributes ∼8% to the Indian economy and employs ∼4.5 million people [41, 30]. Also, multinational corporations are increasingly becoming more inclusive [47], resulting in active policies to hire from the disabled community. Our participants also mentioned the suitability of their technology job roles as they required limited communication.

Our participants relied on technology as their primary mode of communication, utilizing emails, WhatsApp video calls, and teleconference calls to connect with colleagues and friends. They were also active users of online food delivery and cab booking services. However, they often faced accessibility issues with existing technologies and provided suggestions for improvement. For example, they proposed features like pinning interpreters in teleconferencing platforms and receiving feedback in video calls if their hands are getting cropped from the live video feed. With the rise of hybrid workplaces, technology will continue to play a significant role in the lives of DHH individuals. It is important to note that while technology facilitates communication, connection, and employment for our

participants, it also has the potential to contribute to social isolation [9]. The existing barriers of sign language further amplify these challenges for the DHH community [7]. Interestingly, technology served as both an enabler for communication, connection, and employment, as well as a facilitator of isolated work with minimal communication requirements in the workplace.

5.1   Designing Inclusive Technology

Given the diverse needs and constraints in India, it is crucial to collaborate with NGOs and end users to iteratively develop tailored technological solutions.

Interpreters on Demand: Access to an interpreter emerged as the most reliable solution for the DHH community. All of our participants mentioned the ease of interacting with hearing individuals in the presence of an interpreter and the reduction in anxiety during such conversations. However, constant accessing interpreters is infeasible due to the high cost of hiring an interpreter and the dearth of certified interpreters in India [40]. Technologies like on-demand online interpreter[6] have potential to address this. It is expected that such on-demand hiring would reduce costs as interpreters are able to serve more people more efficiently. Privacy concerns on such a platform can be alleviated by anonymizing both the DHH user and the interpreter with generative avatars. While an early prototype solution is available in India[7], none of our participants were aware of it. We believe that a platform for on-demand interpreters that pays the interpreters fairly while efficiently interfacing them with DHH users will be very effective in meeting several challenges that our work identifies.

Ambient Conversation: There are other situations like informal social conversations with colleagues at workplace (such as at the water cool) which do not warrant an interpreter, but enable building of relationships and mental well-being at work. Smartphone apps (like Talk to Deaf[8]) enable DHH users to listen to ambient conversations, by using STT technology to display captions for conversations happening around the user's smartphone. However, we found that these apps to be limited in their utility as they work only when spoken directly into the smartphone's microphone. Improved microphone technology for indoor settings is available on consumer-grade smart speaker devices, which can be adapted to enable the DHH to listen in to ambient conversations.

Accessible Video Conferencing Platforms: Our participants utilized speech-to-text (STT) technology in video conferencing platforms to auto-generate live captions during office meetings. However, participants with limited English proficiency found it challenging to read the captions at the required pace. A possible solution is to provide a history of the generated captions for later reference, however that still limits active participation. A more technically challenging solution would be to integrate automatic tools for real-time text simplification [65] such as Lexi [6]. Prior research on the accessibility of videoconferencing platforms has

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[6] Jeenie: https://jeenie.com/

[7] SignAble: https://play.google.com/store/apps/details?id=org.signable.apprtc

[8] https://play.google.com/store/apps/details?id=unique2040.com.text2speech

identified barriers to inclusive meetings such as insufficient frame rates required to understand sign language, identifying active speakers based on audio, and sub-optimal presentation of visual sources [51]. Proposed design considerations include customizable layouts to consolidate visual information [10].

Accessible Phone Calls: While efforts to build novel applications to improve accessibility continues, several problems can be solved by designing existing applications more inclusively. In particular, a majority of our DHH participants faced challenges in interacting with cab drivers and food delivery personnel over phone calls, and have to seek help from family members, work colleagues, or strangers. These service apps should add a "Do not disturb/DHH mode" informing the driver/delivery personnel that the service requester is a DHH individual. In such cases, communication should be automatically restricted to text messages, instead of phone calls. More generally, our participants pointed challenges in attending audio phone calls. Recent smartphone apps (such as Rogervoice[9]) attempt to make audio phone calls accessible for the DHH community. Rogervoice auto-generates captions for incoming audio calls, and the DHH person can either talk to the caller or type out a message that is read to the caller using TTS technology. Unfortunately, no similar app is available in India. The technological barriers to build such an app are higher in India, given the diversity in spoken languages and accents, and presence of code-mixing.

6   Conclusion

In this work, we study the challenges faced, workarounds, and role of technology in the life of employed DHH Indians, by interviewing 15 DHH participants and surveying 131 DHH respondents. We emphasize the specificity of our study here as a reminder to readers that this study is at best a first step towards characterizing accessibility challenges for the DHH community outside of the developed regions context. Our study reveals various challenges faced by the Indian DHH community on a day-to-day basis, in a variety of work-related settings. Specifically, we highlight technology-related challenges with video conferencing applications, automated captioning services, audio phone calls, and app-based service delivery, along with workarounds. We also discuss foundational challenges due to the stigma associated with signing in India and problems arising due to linguistic variations in ISL and English. We conclude by proposing technology and design recommendations to tackle the identified challenges.

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[9] Rogervoice: https://play.google.com/store/apps/details?id=com.rogervoice.app

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