Silent Delivery: Practices and Challenges of Delivering Among Deaf or Hard of Hearing Couriers

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This paper explores the motivations, practices, and challenges of Deaf and Hard of Hearing (DHH) couriers in China's food delivery industry. Interviews reveal a preference for this industry due to better pay, job satisfaction, and community belonging. DHH couriers tend to and frequently disclose their DHH disability using platform tags and text messages. They also utilize accessible communication tools provided by the delivery platforms, such as AI voice calls, voice-to-text technologies, and electronic communication cards, to facilitate communication during the delivery process. Despite these technological aids, human intervention remains crucial throughout the delivery process. Challenges encountered include safety risks when riding mopeds, the complexities of multitasking, and user mistrust in AI voice calls. Our findings offer valuable insights for designing more inclusive delivery platforms and have broader implications for creating employment opportunities for DHH, particularly in developing countries.

Additional Key Words and Phrases: Accessibility ; Individuals with DisabilitiesAssistive Information and Communication Technologies ; Empirical study that tells us about people ; Qualitative Methods

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1 INTRODUCTION

In recent years, a growing number of online platforms offer food delivery services in various countries. In China alone, the number of people engaged in food delivery work has reached 7.38 million [36][14]. Notably, an increasing number of Deaf and Hard of Hearing (DHH) individuals in China have taken up courier roles. Currently, nearly 100,000 registered DHH couriers are employed in the country[47].

In China, the employment of the DHH population has been a long-standing challenge, and it persists today. A major issue is their limited access to information [41], coupled with the fact that only about 1% have a higher education[16]. Many encounter explicit or implicit discrimination from employers during the recruitment process [1]. Currently, the employment rate for people with disabilities in China stands at only 30.4%, with the employment rate for the DHH individuals even lower than this percentage[37].

Many DHH individuals are now finding new employment opportunities in food delivery. While previous researchers have explored the motivations and challenges of disabled workers in platform labor[41], few have delved into the unique experiences and challenges faced by DHH couriers in their communication efforts. Especially in the context of food delivery work in China – couriers primarily use electrical mopeds, and they also need to deliver enough orders to earn an adequate income due to the low average income per order[25][8]. In the delivery process, DHH couriers often employ an array of tools and strategies, either individually or in combination, to address their hard of

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hearing[1]. For example, they need to obtain or convey order information, navigate routes, and communicate with customers and merchants. Couriers use Information and Communication Technologies (ICTs) [39] to assist them in communication. Previous research [4][42][31][50] has mainly focused on applying ICTs to assist DHH people in traditional online-device-supported contexts. In this kind of platform-mediated context, there is a need for frequent back-and-forth interactions between online and offline domains, obtaining information from online platforms, and communicating with customers, merchants, and station managers offline. Therefore, We conducted semi-structured interviews with six DHH couriers and four station managers in China. We summarize our research questions below:

- What motivates DHH people to work as couriers?
- What are the practices of DHH couriers? Specifically, how do DHH couriers complete food delivery work with assistive Information and Communication Technologies(ICTs)?
- What challenges do DHH couriers face?

Our interviews reveal that DHH couriers are primarily motivated to enter the profession due to the prospects of low entry barriers, better wages, and an enhanced sense of community, belonging, and social identity. They actively disclose their DHH status to customers, believing that this fosters understanding and minimizes the need for verbal communication. This identity revelation is further facilitated by platform features such as the "DHH Identity Tag on Tracking Page" and self-disclosure text messages. In their workflow, they employ various technological tools such as AI voice calls, voice-to-text technology, and electronic communication cards. Simultaneously, there is significant human intervention, especially during peak hours, such as manager intervention, to aid in the communication process. Yet, these couriers face challenges like higher traffic risks due to their lack of sound awareness, difficulties in multitasking, distrust from customers towards AI voice calls, and the added stress and risks associated with seeking external support during deliveries.

2 BACKGROUND AND RELATED WORK

2.1 Food Delivery and DHH Couriers in China

Food Delivery Work is generally managed and organized through an online platform.[25]. Compared to American or European models, Chinese food delivery work has unique features, including their massive scale, different types of vehicles, longer working hours, and lower hourly wages. China's food delivery industry has a considerable scale, with 535 million online users (49.6% of the total online population) as of December 2023[9]. Meituan and Ele.me dominate 90% of the food delivery market in China, making it difficult for couriers to avoid the impact of algorithms through platform switching strategies. Most food delivery couriers in China primarily use electric mopeds instead of cars for deliveries, further lowering the economic barriers to entry into the food delivery industry[25]. Using electric mopeds has also led to couriers engaging in risky driving behaviors such as riding against traffic, speeding, and running red lights. However, compared to other countries, the per-order earnings for food delivery couriers in China are relatively low, typically around 3-4 CNY(about 41cent-55cent) per order. This results in lower hourly wages, which are typically in the range of 20-30 CNY(about 2.75-4.13 dollars) per hour. To ensure their income, couriers often need to work long hours, and in China, couriers typically have 2-4 days off per month[8].

As Kalle Kusk and Midas Nouwens described in their literature review of Food Delivery Work in CSCW, algorithmically assigned food delivery work practice usually has some core characteristics. These include pay-per-delivery Pay structures, the datafication of delivery processes for Real-time algorithmic management, and Flexible scheduling to match demand with labor supply[25].

In the context of the widespread belief that structural imbalances and the expansion of capitalism are inevitable, scholars have been working to strengthen the means of intervention[30]. Shuhao Ma et al. studied the intervention factors of Portuguese food delivery riders in the delivery process, in which human factors played an important role[32]. Samantha Dalal et al. explored the key role of human intervention in Platform food delivery through a case study, including the intervention of stakeholders such as Restaurants, Couriers, Customers, and Platform Administrators[10]. In a full-time delivery ecosystem, the Regional Workstation is the command center, where delivery services for a designated area are coordinated. The Station Manager takes on responsibilities for courier management and order scheduling. In addition, the couriers' self-intervention and peer support will also intervene in regulating the food delivery process. The role of these human interventions is indispensable in the food delivery system, and researchers have explored different methods of intervention by various roles in the delivery process in different contexts (Table.1).

Character	Methods of intervention
Self Intervention	Couriers intervene through their own accumulated experience[17] Couriers engage in platform rotation and algorithm gaming across different platforms[52] Couriers turn down certain jobs because they are expected to be more profitable[52] Couriers leave the platform when they are offered undesirable jobs[52].
Peer support	Informal socialization with peers while waiting in restaurants can provide experience and information[17]. Experience sharing among peers with similar cultural backgrounds in Culture-Based Networking[32].
Manager Intervention	Managers monitor for rule violations through platform surveillance and issue telephone warnings[17]. Managers monitor for algorithm failures through the platform, flexibly adjust order deliveries, and communicate with couriers during shifts[10].

Table 1. Different methods of intervention by various roles

Previous research on delivery couriers in China primarily focused on enhancing delivery efficiency through platform algorithms. For example, Chengliang Gao and Fan Zhang et al. use deep learning to predict each feasible location the courier will visit next.[18]. Zhiqing Xie and Haiyong Luo et al. introduce a floor localization system to provide real-time, accurate 3D positioning services, thereby boosting the courier's delivery efficiency[55]. While some other work, like Lin, Pearl M.C. et al., report the work goals, practices[29], and significance of Chinese couriers. However, the unique needs of marginalized couriers, such as the DHH couriers, have been largely overlooked. Given their need for intense interaction with people, platforms, and technologies, it is crucial to examine whether current platforms adequately support them and if human interventions can alleviate challenges.

To date, the HCI and CSCW community has yet to explore the motivations, practices, and challenges of DHH couriers. But contextual and platform-specific differences fundamentally influence and shape the practice of food delivery work[25]. So, our study aims to fill this gap by investigating the specific practices, and motivations of DHH riders in China to choose food delivery as a full-time job. Starting from the differences between China's local environment and

monopolistic platforms, our research explores the particularity of the work practices of Chinese takeout riders [25]. In addition, as an underrepresented group in the food delivery community, how to influence the practice and perception of DHH riders through design and intervention means is also worth exploring.

2.2 HCI, Disable Workers in Platform-Mediated Work, Accessibility for DHH

Researchers are realizing that the focus on high efficiency is detrimental to workers in platform-mediated works[3]. Through qualitative interviews, the HCI domain highlights the importance of a worker's perspective to reevaluate existing platform algorithms and tools, and co-design with workers for better mental and physical health[56]. Researchers also noticed the large number of disabled workers. Shruti Sannon and Dan Cosley focus on the motivations and practices of disabled workers in platform-mediated work. The low barrier is the biggest motivation, as they face reduced disability discrimination often encountered in traditional recruitment settings.[41] Additionally, work flexibility can help mitigate some of the time, space, and social challenges associated with traditional fixed employment, providing disabled workers with opportunities to earn essential income. The review by Shruti Sannon et al. suggests that workers with disabilities face the same challenges as non-disabled workers: a lack of control and agency in the face of ability-unaware algorithms, and mismatches between customer expectations and worker abilities that lead to unfair evaluations. However, these challenges are amplified for workers who must also account for additional disability-related requirements. Moreover, due to platforms not typically considering accessibility in their designs, they may assign inaccessible tasks to disabled workers, resulting in these workers having to invest additional costly labor[41].

Communication is the most significant barrier for the DHH people in social labor. In Kelly Mack et al.'s review of accessibility literature in CHI and ASSETS from 1994 to 2019, common research objectives include increasing digital access through technology innovation, understanding user needs, preferences, and abilities, increasing physical world access, increasing independence, supporting communication, personal informatics and/or behavior change. While literature supporting communication constitutes a relatively small portion (16%) of accessibility research, in the context of accessibility literature focused on the DHH community, nearly two-thirds (64.9%) of it pertains to supporting communication. This high proportion underscores the significance of accessible communication for the DHH population[33]. DHH people can employ various communication methods, such as sign language, speech, text, assistive devices, video, and tactile languages, independently or in combination[35]. Chanchal Agrawal and team categorized DHH communication into Visual and Text-based methods[1]. Aashaka Desai and colleagues, on the other hand, focus on the interplay of accessibility communication methods. They investigate the interaction between speech-to-text and automatic captions in online environments, emphasizing the significance of communication methods' interdependence in providing access[12].

Research on the well-being of workers with disabilities and support for accessible communication both play an important role in addressing the economic, physical, and social issues of the DHH people. Few previous studies focus on the practice of DHH people in Food Delivery Work, and researchers have yet to understand the barrier-free communication challenges of DHH people in completing food delivery tasks in platforms with unequal power. Communication barriers for DHH people can potentially amplify or exacerbate the harm to workers' well-being. Therefore, this work aims to integrate the literature on the well-being of disabled workers and support for accessible communication to understand how the DHH people engage in Food Delivery Work and the role of ICTs in their working experiences.

2.3 Assistive Information and Communication Technologies for DHH

Information and Communication Technologies (ICTs) assist DHH in accessible communication. Sarah Andrew's team has demonstrated that in customer service environments where speech communication is the sole mode of interaction, the DHH community encounters challenges verifying their identity through speech. They must seek assistance from interpreters through technologies like Video Relay Service (VRS), which can introduce privacy and security risks[2]. Universal technological means that support communication between individuals with hard of hearing and those without generally include real-time captioning, bidirectional speech-to-text transcription[24], and sign language interpretation[4], result in bridging text/sign language with voice[12].

The assistance of ICTs provides DHH people with better visual notification[4], attention-sensitive UI[50], and AR/VR applications[38][31]. Many ICT programs offer DHH people the possibility to improve their speaking and interpretive performance and overcome the hearing information gap(Table.2). For example, DHH people actively participate in online co-design workshops to explore the integration of Automatic Speech Recognition (ASR) into mobile and videoconferencing technologies. In these workshops, innovative accessibility enhancements, such as rectifying ASR errors and introducing a notification system can influence speaking behaviors positively [42]. Chanchal Agrawal and Roshan L Peiris' review mentions that in a classroom context, DHH students focused only 10% on/around the instructor, 14% on slides, and they primarily directed their attention towards the interpreter[1]. Garreth W. Tigwell and colleagues developed an attention-sensitive user interface where students can anchor the video window on the screen and receive real-time visually engaging cues, enhancing the visual attention of DHH students[50]. Similarly, Le Luo et al. and Prajwal Paudyal et al. found that the application of ICTs, such as live AR Avatar Interpreter and VR classroom environment prototype system, facilitated information exchange between DHH students and hearing Instructors, leading to increased efficiency and student attention luo2022avatar[38].

Another area of research has a macro objective on how ICTs have enabled DHH people to get dignified identity reveal, self-disclosure, and even collaboration with hearing people. For example, Ken Takaki et al. designed and developed 'asEars,' a bone conduction-based device to be worn with eyeglasses. They found that this unconventional style of hearing aid could prompt inquiries from others[45]. In such a context, the other person did not assume that the wearer had a hard of hearing, which provided a communication opportunity for self-disclosure. Moreover, revealing their DHH identity can be challenging, especially in the workplace when dealing with unfamiliar customers. Sooyeon Lee et al. examined DHH drivers in Uber experience and found that they face challenges when communicating their hearing status to riders. DHH drivers often use in-app text or labels to communicate their identity. Sharing order completion details with riders can ease the disclosure burden for DHH drivers.[27]. Prior studies have focused on applying ICTs to assist DHH people in traditional online-device-supported contexts, such as video conferences[50], virtual classrooms[38], and other collaborative works[42]. However, ICT-assisted food delivery work faces frequent interactive interplay with information and stakeholders, including accessing information online, communicating with people offline, and dropping food at places on time. In addition, the limited hearing abilities of DHH people result in fewer information channels available to them. The challenges were compounded by the fact that many mainstream platforms employ low-cost, high-efficiency algorithmic management strategies These features enable the DHH couriers community in Food Delivery Work to address various accessibility problems effectively and, when necessary, utilize technologies or seek assistance from others' intervention. Therefore, our research examines what/how ICTs assist DHH couriers, and when human intervention is needed to overcome barriers, especially in their communication, identity-reveal, self-exposure, and personal gratification.

Contexts		ICTs	communication means
Education	Offline Classroom[31][38]	VR/AR Helmet Mounted Display(HMD) Speech-to-sign Language Translation	VR/AR avatar interpreter
	Remote learning[50]	Video Conferencing	Better UI design in online conference
Collaborative Work	Online community[46]	Videos	Sign Language videos Content Creation
	Group[42][35]	Video conferencing Automatic Speech Recognition(ASR) Online Collaborative Whiteboarding Tool	online conference
Parent–DHH Child[4]		Near-Object Projection Haptic Indicator	Face-to-face interactione
(Uber) Gig Work[27]		Speech-to-text Technology Video Relay Services(VRS)	Face-to-face interaction

Table 2. ICTs applied in different contexts

3 METHODS

In order to comprehend the practices, motivations, and work-related technological challenges faced by DHH couriers, we observed the working flows of two DHH couriers during a four-hour ride-along and conducted a qualitative semi-structured interview-based study of six couriers and four station managers. A prior brief survey is introduced to collect personal information, including age, gender, DHH condition (this state follows the DHH classification of Chinese Practical Assessment Standard for Disabled Persons), and the main delivery platform. These observations and a general survey helped us collect contextual information on the field before the interviews and enabled us to ask the DHH deeper and more focused questions regarding their practices. To ensure the accuracy and comprehensiveness of our research, we referenced Becca Dingman et al. and Beiyan Cao et al. 's study on interviewing DHH [13] [5]. We deliberately designed questions with clear meanings, avoiding leading questions since DHH might find nuanced semantics challenging to understand and convey.

3.1 Observing the DHH Couriers' Working Flow

To reach for DHH couriers, we initially used Google Maps to locate stations around the researcher's school and, through a snowball sampling method, identified sites employing DHH couriers. We visited 6 stations in Hangzhou to understand the quantity and basic characteristics of DHH couriers. Across these six stations, we found nine DHH couriers, all of whom were male. Interestingly, when researchers asked about their origins, during the experiment conducted in southern China, five DHH couriers were from northern China (P1, P2, P3, P4, and P5). Subsequently, they highlighted the common occurrence of individuals from underdeveloped areas in northern China seeking job opportunities in the south. Moreover, they expressed concerns about regional differences in sign language between northern and southern China (further detailed in Section 4.3.3). To comprehend the specific practices of DHH couriers in their actual work processes, we initially observed the work practices of two DHH couriers from the Ele.me platform.

With the consent of the DHH couriers, the first author followed the DHH couriers on an electric moped. Work practices were documented via cell phone and tracking video placed on the mount of the electric moped. The overall 4

ID	Gender	Age	Work Category	Platforms in Use	Years of Working	DHH State
P1	M	29	Courier	Ele.me	9 months	I
P2	M	32	Courier	Ele.me	2 years	I
P3	M	28	Courier	Meituan	1 month	I
P4	M	35	Courier	Meituan	2 months	I
P5	M	30	Courier	Ele.me	2 years	I
P6	M	24	Courier	Ele.me	4 months	I
S1	M	40	Station Manager	Ele.me	10 years	/
S2	M	Not disclosed	Station Manager	Meituan	Not disclosed	/
S3	M	38	Station Manager	Meituan	10 years	/
S4	M	Not disclosed	Station Manager	Ele.me	Not disclosed	/

Table 3. Summary of Participants. Among the 10 participants, all of them are male, aged between 24 and 40. P1-P6 are DHH couriers, all categorized as DHH State I, indicating a speech recognition rate below 15%. DHH State II corresponds to a speech recognition rate between 15% and 30%, DHH State III represents a rate between 30% and 60%, and DHH State IV indicates a rate between 61% and 70% (these states follow the DHH classification of the Chinese Practical Assessment Standard for Disabled Persons [48]).The remaining S1-S4 are station managers with full hearing abilities.

hours cover 6 round trips, each trip is 30min to 50min, 1-4 orders per time, 18 orders in total. During the observation process, we focused primarily on:

1) How do DHH couriers pick up restaurant meals and deliver them to their customers? How do they communicate and what is the nature of their communication?

2) How does DHH courier communicate with people through ICTs?

3) What else would assist DHH couriers other than ICTs?

While observing DHH couriers during food deliveries, we recorded their interactions with merchants and customers, including gestures and assistant technology use. We took photos to facilitate further analysis. Additionally, we maintained privacy by anonymizing the data and concealing faces and road information.(Fig.1)

3.2 Interviews with DHH Couriers and Station Managers

We invited six DHH couriers and four station managers to participate in semi-structured interviews through offline recruitment combined with snowballing (Table.3). We obtained informed consent from participants before the interviews. Our interviews were conducted between May 5, 2023, and June 25, 2023. Each interview lasted one to two hours, and text and voice data were recorded for later analysis. DHH participants can choose from three interview methods: 1) online WeChat texting (an instant messaging service), 2) offline face-to-face with support for DHH couriers through interpreters at the same location, and 3) offline face-to-face through WeChat texting at the same location. One DHH courier among the DHH participants chose 1), and the other five DHH couriers chose 3). Station managers had the option of choosing either an online meeting or an offline face-to-face interview, and they all chose to conduct the interviews offline at the station. We used different interview outlines for the semi-structured interviews for the DHH couriers and station managers. With the DHH couriers, we cover five topics: Work Motivation, Process and Practice, Communication and disclosure, Challenges and Solutions, and Peer and Management Interaction. With station managers, we focused on their job responsibilities, observations of DHH courier performance, and interventions at work, including colleague relationships, station management, and work performance. After the interview, each participant was compensated 150 CNY (about 21 dollars).

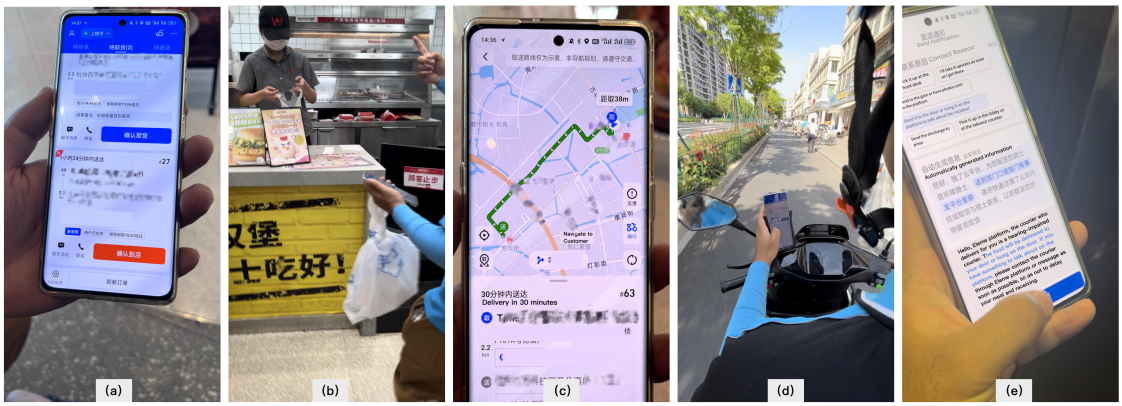

Fig. 1. Representative moments in the delivery process. (a) A DHH courier reviews pending pick-up orders and merchant addresses within the platform. (b) Upon arriving at the restaurant, the courier stands at the counter, raising their right hand to attract the merchant's attention. (c) The courier uses the platform's integrated Amap feature to navigate to the customer's location. (d) As the DHH courier rides, they multitask by using their left hand to check their phone for any new orders. (e) Upon arrival at the customer's address, the courier selects a preset message option, triggering an AI voice call to notify the customer for meal collection

3.3 Data Analysis

We used an empirical, in-depth qualitative analysis of the collected data to explore DHH courier's experiences in food delivery work. Based on McDonald et al.'s guidelines for qualitative analysis in CSCW and HCI practice[34], our analytical procedures did not focus on inter-rater reliability, and the main aim is not to create consistent codes but eventually yielding concepts and themes (recurring themes or meanings that represent phenomena). Our data contains audio recordings of station managers and informational texts provided by DHH couriers. The researchers used an IOS phone to record the station manager's interview and transcribed the transcript verbatim into Chinese via DingDing (a voice transcription platform), and the transcript was de-personalized. The recordings were then reviewed in an overall context by four native Chinese speakers.

We analyzed all collected interview data in the following steps: 1) We read the collected data line by line to get a general idea of the experiences of station managers and DHH couriers during delivery tasks. 2) Two researchers performed open coding for each piece of data, using MAXQDA to categorize participant responses and highlight similarities and differences in the concepts and themes that emerged from participant descriptions. 3) Three key concepts of motivation, practice, and challenge described in the Introduction section show us how to merge and organize these themes. These three themes are widely used in research on practice perspectives in the HCI field[26], and we also focus on the key role of the materiality of people and artifacts in the practice theme[49], which is highly relevant to the context of DHH courier distribution practices. However, it should be mentioned that we did not use these three themes as a priority to map our data. Instead, these themes naturally emerged from our data. 4) Finally, we performed focus coding to extract quotes based on similarities and differences from the previous steps. We used these quotes to synthesize the motivations, practices, and challenges of DHH couriers' participation in platform delivery efforts to answer our research questions.

3.4 Positionality Statement

Before we present the findings, and by recognizing the uniqueness and sensitivity of the DHH group, we acknowledge our standpoint as None-DHH people but have long experience communicating with them and empathizing with them. The first author supervised a DHH graduate student for three years, and the other two authors experienced communication difficulties while receiving deliveries from several DHH couriers. This led two team members to establish daily WeChat contact with nine DHH couriers from nearby delivery stations, gaining insights into their communication methods and work conditions. Our team also followed over 30 DHH courier bloggers on Red and Douyin (two of China's social media platforms), noting common issues. Despite the absence of DHH members in our research team, we strongly empathize with this particular group and believe in the need for a more sustainable and equitable societal structure. We emphasize inclusive and sensitive research methods because we know our role and its limitations as external observers. Our approach combines investigative literature [6][22], interactions with the DHH community, and expert discussions to compensate for our team's perspective limitations, ensuring the comprehensiveness and authenticity of our research.

4 FINDINGS

In this section, we present the findings regarding the motivations, practices, and challenges of DHH couriers. Firstly, in Section 4.1 (RQ1), we provide an overview of the three main motivations for DHH people to choose a career in the courier industry. Section 4.2 (RQ2) then elaborates the ways DHH couriers navigate identity disclosure, exploring the roles of accessible communication technologies and human intervention in their workflow. Finally, in Section 4.3 (RQ3), we detail the challenges faced by DHH couriers in their work.

4.1 Motivation

We found that DHH couriers engage in courier work primarily due to the low entry barriers to employment and better wages. Furthermore, a frequently mentioned unique motivator for becoming a courier is referrals from within the DHH community. Better wages and a sense of belonging within the DHH community were the two most frequently cited reasons for keeping them in this job.

4.1.1 Low Entry Barriers to Employment. The low entry barriers to employment in the food delivery courier work provide the DHH community with a relatively easy opportunity to enter the job market. Most DHH people in China have not received higher education [16]. Among our DHH participants, P1, P5, and P6 have a junior high school education, P2 and P3 have a primary school education, and P4 has a vocational college diploma. Our participants expressed that due to their lack of a solid educational background and the inability to use spoken language for communication effectively, they found it challenging to obtain the same job opportunities as hearing people and often faced subtle workplace discrimination. Many DHH people turn to jobs that require less interpersonal communication, such as manual labor and assembly line work.

The burgeoning food delivery industry in China has increased demand for delivery couriers. These platforms, acting as an intermediary, have opened numerous job opportunities. Our participants highlight that the requirements for becoming a delivery courier are minimal, not necessitating high educational qualifications but simply requiring basic smartphone skills and the ability to ride a moped. Some participants mentioned that these minimal entry requirements have opened new employment avenues for the DHH community with lower educational backgrounds. P3 said, *" Even*

though I only have a junior high degree and can't hear anything, I was successful in my first application for the courier job; I'm so surprised."

Additionally, many participants highlight that the primary responsibilities of a courier, involving riding to pick up and deliver meals, are comparatively less physically demanding than manual labor. Coupled with the flexibility in choosing working hours, this type of job has attracted many DHH workers who previously engaged in manual labor to switch careers and join the courier workforce. P2 and P5 were former colleagues in the freight yard, doing heavy physical labor for three years. They mentioned that the courier's work is physically easier than before. P2 added, *" I used to work as a stevedore and was tired every day. I heard couriers don't need as much physical effort, so I switched to becoming a courier."*

Some DHH couriers found that not only does courier work have relatively relaxed entry requirements, but it also avoids the strenuous nature of their previous manual labor.

4.1.2 Better Wages . The food delivery courier job provides the DHH community with better wages, which is the most frequently mentioned reason by our DHH participants. As mentioned in the previous section, some DHH people might have previously engaged in manual labor and assembly line work. These jobs offer meager and monotonous income, with monthly salaries typically ranging from 2,000 to 5,000 RMB (300-750 dollars)[54].

The income model for couriers is based on a per-order payment system, earning 3 to 5 yuan (0.43-0.72 dollars) per completed order. Our DHH courier participants note that after an initial familiarization period, they can handle 30-50 orders per day or even more, comparable to hearing couriers. Therefore, the average monthly income for DHH couriers can reach about 5,000 to 10,000 RMB (750-1500 dollars), significantly higher than their previous jobs. P4, who has been working in the supermarket for four years, said:

> *" When I worked as a stock clerk at the supermarket before, my wage was fixed. However, with courier work, the more deliveries you make, the more you earn, so I want to make more money."*

To achieve such income levels, some DHH couriers participants emphasize the need for a transition and familiarization period, along with some necessary self-adjustment of their time slots (details of this are elaborated in Section 4.2.3 (1), titled "Self-Intervention of DHH Couriers"). Additionally, some customers provide extra tips due to the exceptional performance of DHH couriers, further increasing their income. P2 shared: *" Once a customer knew I was a DHH courier, said I was doing a good job, and gave me a tip, which I have been rewarded 11 times."*

Therefore, our DHH participants express that choosing to become a courier is not only due to the better wages this job can provide but also because it offers autonomy and flexibility. They can adjust their workload and income according to their will and capabilities.

4.1.3 Community Belonging and Social Identity. Many DHH people learn about this profession by watching the work vlog of DHH courier bloggers on short video platforms or are influenced by recommendations from DHH courier friends to join the courier industry.

We found that some DHH couriers, in their spare time, record and share their work and life on short video platforms like Douyin (Chinese version of TikTok). They aim to enhance their sense of social participation through these short videos, demonstrating to the public the diligent work and positive lifestyle of DHH people to improve public perception of the DHH community. At the same time, this attracts more attention from other DHH people and encourages them to join the courier industry. P4's use of Douyin exemplifies this:

> *"On Douyin, I have 200 fans. While it's a modest number, their support not only boosts my sense of belonging but also shows many in the DHH community that delivering couriers is a viable career."*

Our participants also highlight that peer support and job recommendations within the DHH community are significant social characteristics. Experienced DHH couriers assist newcomers in familiarizing themselves with work procedures (see details in 4.2.3 (2) Peer Support among DHH Couriers). Additionally, DHH couriers who are already employed are often willing to recommend their DHH friends to join the industry.

P2 not only recommended P5 to join the courier industry but also invited other DHH friends to join. P2 mentioned, *"I recommended courier work to my DHH friends who were previously engaged in manual labor, telling them that this job is not as exhausting and is worth considering."*

Thus, we found that peer support and job recommendations within the DHH community assist in familiarizing them with work procedures, helping DHH people get employed, and further enhancing the sense of belonging and cohesion within the DHH community.

4.2 Practice

4.2.1 Identity Revelation to Customers. Couriers often need to handle customers' voice calls during delivery, typically for inquiries about meal delivery times or to modify order details. However, DHH couriers, due to their hard of hearing, are unable to respond to customer calls using voice. We discovered that some platforms and most DHH couriers have adopted a proactive identity revelation strategy, encouraging customers to opt for communication methods other than voice.

(1) DHH Identity Tag on Tracking Page. On the Ele.me platform, when an order is assigned to a DHH courier, the platform notifies the customer of the courier's communication impairment through an identity tag feature. This feature aims to enhance customer understanding while informing them that the courier cannot engage in verbal communication.

DHH participants working with Ele.me mentioned that they need to upload disability identification for verification on the Ele.me platform. Once authorized as DHH couriers, when they accept orders, customers can see a DHH identity tag along with the delivery progress on the order tracking page. The DHH identity tag says "我是沟通障碍骑手，请多多包涵" , which means "I am a courier with communication difficulties. Your understanding is greatly appreciated." (Fig.2a).

Our participants perceive this feature as designed to encourage them to communicate primarily through text messages, thus reducing the burden of answering voice calls. P2's experience reflects the positive impact of this feature:

> *"It does reduce voice calls, and when handing over the goods to customers, some customers even use a thumbs-up gesture or send messages to encourage me, which makes me feel warmth. However, some customers do not pay attention to system label prompts and still choose to make voice calls to me."*

Some participants pointed out that although this feature can alleviate some of the burdens of voice communication for DHH couriers and also help increase customer understanding, it can only partially prevent customers from making voice calls. In this case, DHH couriers still need to use preset messages or type messages to customers .

(2) Self-disclosure and Preset-reply by Text Messages. Not all platforms have the identity tag feature, and customers can easily overlook these tags provided by the platform. Therefore, some DHH couriers prefer proactively disclosing their identity information to customers through preset messages, in the hope of facilitating communication via text messages.

Our participants indicated that the preset message feature could be utilized within the messaging functions of platforms or on some brand smartphones (like Xiaomi; Huawei, etc.). A common preset message is "I am a courier with communication impairment. Please contact me via text message, thank you." Primary uses of preset messages are as follows: At first, some DHH couriers use them right after accepting orders to prevent incoming calls from customers; secondly, preset messages are used during critical communication moments, such as informing customers of meal delivery; and finally, in unavoidable situations, such as after hanging up a customer's call, they are used to explain (Fig.2b).

Some DHH couriers proactively contact customers with a preset message after accepting an order, informing them of their communication impairment. P5 talks about his programmatic workflow:

> *" Upon accepting one order, I will send a message to inform the customer that 'I am a DHH courier and can't hear. Please contact me with text messages."*

Many participants note that this pre-emptive communication helps set clear expectations. The effectiveness of this strategy lies in its ability to reduce misunderstandings and let customers choose more accessible communication ways.

Additionally, when receiving a customer's call, some DHH couriers will have to hang up and immediately respond with a preset message. This message explains to the customer that the call was disconnected due to their communication impairment and suggests continuing the conversation via text. Our participants emphasize that hanging up the phone is considered impolite, and without a timely explanation, it could lead to the customer giving a negative rating. P1 shared his work experience:

> *"Customers are usually used to voice calls, so not speaking and hanging up after answering can make them feel confused and disrespected, which may lead to negative ratings. That's why it's important to explain to the customer through text messages promptly; preset messages can save some time."*

We found that DHH couriers use preset messages because this method allows them to quickly convey their communication impairment to customers, reduce voice calls, and provide rapid and timely explanations within the limited delivery time. This approach helps to alleviate customer emotions and thus reduces negative ratings due to communication issues. Our participants also pointed out that if negative ratings are solely due to communication problems, DHH couriers can appeal through the platform. After being reviewed by the station manager and then successfully validated by the platform, the DHH courier can be exempted from penalty charges.

4.2.2 Accessible Communication in Order Processing. Despite platforms using identity tags and couriers sending messages to proactively disclose their DHH status to minimize voice call communication, the nature of food delivery as a time-sensitive service necessitates immediate responses in specific scenarios. In these scenarios, ICTs are extremely useful. These scenarios include DHH couriers: 1) notifying customers of meal delivery, 2) responding to voice calls from customers, and 3) handling inevitable face-to-face communications.(Fig.3)

(1) AI Voice Calls. With the increasing number of DHH people joining the courier industry, some platforms have begun to design assistive features. We found that AI voice call is among the most utilized functions by Ele.me's DHH couriers. Participants highlighted that, as customers are accustomed to receiving food delivery notifications through voice calls from hearing couriers, DHH couriers employ AI voice calls to notify customers. This approach not only enhances efficiency but also aligns with established customer habits.

This feature converts the selected reason for contact chosen by the DHH courier into a voice call. The call content includes the courier's DHH identity, order status, and the location of the food. The call is then initiated by AI, using a

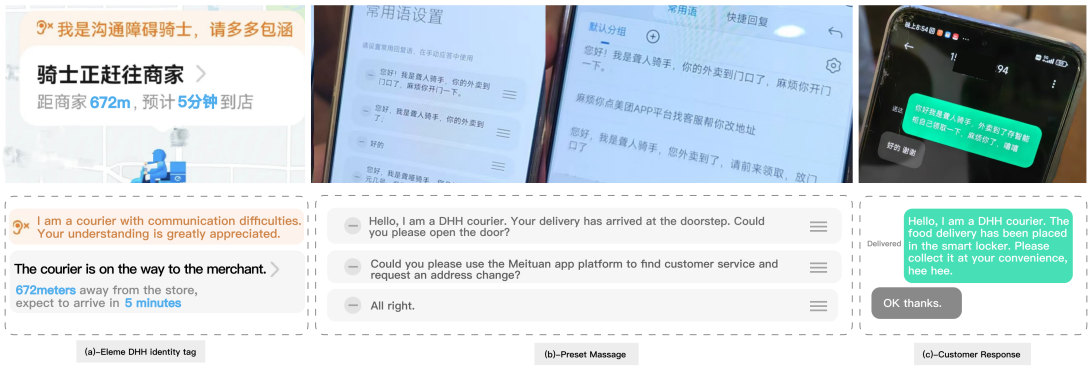

Fig. 2. Identity Revelation to Customers. (a) Ele.me tag,(b) preset messages,(c) customer response

voice call to notify the customer to pick up their meal. A typical call will be like this: Hello, Here is Ele.me. The courier who delivers for you is a communication impairment courier. The food will be delivered to your door or hung on the door. If you need to talk with us, please contact the courier through the Ele.me platform as soon as possible so as not to delay your meal.

Some participants mentioned that including the DHH status of the courier in the AI phone call is also intended to help customers understand why the call is not in a human voice but in an AI-generated voice. P5 added,

> *"I frequently use AI voice calls. These automated calls notify customers of completed deliveries and disclose my identity as a DHH courier. This clarification helps customers understand that my inability to speak results from my hard of hearing, not a lack of courtesy."*

However, this function is not perfect. Some participants expressed that certain customers might feel confused or distrustful of the AI's voice and the virtual number used (see details in 4.3.2 (1) Distrust of AI Voice Calls), leading them to hang up or refuse the call. In such cases, DHH couriers may need to contact the customer again via text message or seek support from the station manager to communicate with the customer. P2 said, *"I can see if the customer answers the call. If they don't, I need to send them a text message or ask the station manager to contact them."*

Despite our participants indicating that the AI voice call feature can improve work efficiency and their preference for using it, there still exists the issue of low customer acceptance and trust in this technology.

(2) Voice-to-Text Technology. Although some couriers and platforms adopt DHH identity-disclosure strategies to reduce the frequency of voice calls from customers, many DHH participants emphasized that numerous customers still overlook these reminders, resulting in them receiving many voice calls daily. S2 notes,*"Many customers disregard platform messages and opt for voice calls, believing them to be more efficient."*

To address this situation, some couriers opt to utilize the Voice-to-Text feature built into their smartphones to answer voice calls from customers. This feature can convert the customer's voice content into text in real time, allowing DHH couriers to access information to understand customer needs visually. The system then converts their typed responses into AI voice to reply to the customer.P6 shares a practical application of this technology:

> *"When customers call, I use the voice-to-text built-in feature of my Xiaomi phone. I could see what the customer wanted from the text, such as asking me to bring cigarettes"*

Some DHH participants have indicated that this feature effectively enhances their efficiency and timeliness in responding to customer needs. However, we discovered that not all smartphone brands have the Voice-to-Text feature. For those DHH couriers who cannot utilize this technology, they typically hang up the call and use preset messages (as stated in 4.2.1 (2)) or type to ask for customer inquiries. Some DHH participants noted that although these methods offer alternative communication means, they are slightly less efficient than voice-to-text and require more time to complete the same communication tasks.

(3) Electronic Communication Cards. Couriers need to frequently engage in face-to-face communication during their work process, such as apologizing to customers for order delays, asking strangers for directions, or picking up meals from merchants. To address the face-to-face communication needs of DHH couriers, some platforms have designed the Electronic Communication Cards feature. DHH couriers select the purpose of communication, and the system automatically generates a complete communication card, quickly informing others about their DHH status and the intent of the communication.

For instance, the DHH courier could simply input the destination to generate a card that reads: "Excuse me, I have a hearing and speech impairment and cannot communicate verbally. Could you please guide me to this location? Thank you for your help." P4 shared,

> *"In densely populated communities, when I can't locate the destination, I will use this electronic communication card. I show this card to the residents, and they kindly guide me using gestures or lead me there."*

Some DHH participants comment that while Electronic Communication Cards (ECC) provide clear and structured textual information, they are only helpful in interactions with strangers. Conversely, when confirming meal preparation time with familiar merchants, simply gesturing the order number suffices, as the merchants understand and respond with gestured numerical estimates of the time. Gesture is considered more efficient and convenient than ECC in such contexts. P1 shares his insights, *"After merchants recognize that I'm a DHH courier, I usually gesture the order number with my hand. It's faster than using a communication card."*

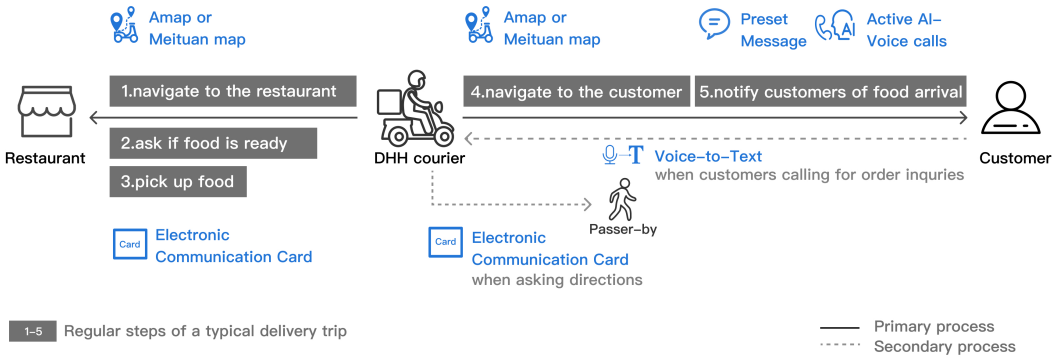

Fig. 3. The assistive communication technology

4.2.3 Human Intervention Complements Assistive ICTs. Although utilizing ICTs enables DHH couriers to avoid or respond to some voice calls from customers effectively, we found that during the delivery process, other approaches like Self-Intervention, Peer Support, and Manager Intervention also play a significant role in communication and problem-solving for DHH couriers. (Fig.4)

(1) Self-Intervention of DHH Couriers. We discovered that in addition to self-intervening in route and pickup sequence management like hearing couriers, some DHH couriers independently arrange the delivery timings of and adjust their working hours to ensure timely delivery and safeguard their safety.

Many DHH participants emphasized that it is often necessary to ask for directions or communicate with community security guards during the delivery process. This is particularly common in densely populated and older residential areas in China, where some complexes have intricate layouts and inconsistent signage, making it difficult for couriers to quickly and accurately locate the delivery address using navigation alone. Although ICTs can provide some assistance, compared to hearing couriers, DHH couriers generally require more time to complete these communication tasks. Consequently, DHH couriers face a higher risk of order delays. To address this issue, some DHH couriers proactively request to deliver 1-2 minutes earlier than the tight delivery schedule to allow time for communication, address confirmation, and other interactions. P2 notes,

> *"I usually arrive 1-2 minutes ahead of schedule. Because it took me a long time to ask for directions before, the order was delayed, and then I would try to reserve time to ask for directions or communicate with the doorman."*

Furthermore, some DHH participants pointed out that they cannot recognize vehicle warning sounds in their environment due to the lack of sound awareness. As a result, a portion of DHH couriers choose to work during off-peak hours, such as in the afternoon or evening when traffic is less dense, to minimize the risk of traffic accidents. P3 explains, *"Because I can't hear it at all, it's dangerous to ride during peak hours, and I usually work in the afternoon or evening when there's less traffic."*

(2) Peer Support among DHH Couriers. A crucial aspect of the working environment for DHH couriers is the robust peer support system, primarily facilitated through digital platforms like WeChat. This support network plays an important role in their professional development and job satisfaction.

Cultural similarity is one of the key factors facilitating peer communication among gig workers[32], and some scholars consider DHH people as a group sharing a common identity and culture [40]. Our participants indicated that DHH couriers often establish connections through WeChat groups, where they share work experiences and assist each other in solving job-related problems. Additionally, experienced DHH couriers help new DHH couriers familiarize themselves with the workflow and other aspects of the job.

Our DHH participants expressed that work experience is significant to them. This is because the tools DHH couriers use for communication with customers differ from those used by hearing couriers, and couriers at the same station are often more familiar with the delivery routes in their area. Therefore, when novice DHH couriers encounter operational issues or cannot find their way, they often consult through DHH courier WeChat group chats or engage in video calls with experienced DHH couriers using sign language for consultation and communication. Sharing experiences and mutual assistance is highly beneficial for them in adapting to the work environment and improving work efficiency. P5 shares his solution:

> *"When I encounter operation problems, I would consult my courier friends via sign language video calls. I'm most comfortable communicating with sign language. Having the phone on the moped's mount makes it very convenient, which is more time-saving than typing and asking the station manager."*

Additionally, some participants mentioned that experienced DHH couriers guide newcomers, teaching them how to use ICTs tools and accompanying them on deliveries. This helps novice DHH couriers familiarize themselves with the workflow more quickly and enhances their sense of community belonging. P2 said,

> *"When I was new, an experienced DHH courier would accompany me to deliver orders and teach me how to use assist communication tools to interact with customers and merchants. He also accompanied me for two days of deliveries, meticulously instructing me on how to operate the system and familiarizing me with the delivery process."*

Currently, P2, with two years of work experience, has carried on the tradition of helping newcomers. He said: *"I will help them get familiar with the work process and teach them the work experience I have accumulated. I also feel a sense of accomplishment."*

(3) Manager Intervention of DHH Couriers. Although DHH couriers can handle some customer inquiries or convey order statuses to customers through ICTs (as mentioned in section 4.2.2), Manager Intervention plays a significant role during peak order times or when resolving more complex customer issues.

Our participants highlighted that couriers often deliver 5-10 orders per trip simultaneously during peak order times. In such tight delivery schedules, DHH couriers, who primarily communicate via text messages, find it difficult to respond to all customer inquiries simultaneously. To manage this situation, DHH couriers typically contact their station manager via WeChat, requesting them to call customers, understand their needs in detail, and explain the situation. The station managers then text these customer requirements to the DHH couriers. This approach helps save communication time and reduces the risk of order delays. S2 explains: *"We have only 30 minutes from order to delivery. I called the customer and translated his request to the DHH courier. It slows the whole process, but it's essential for order completion."*

Simultaneously, we discovered that station managers also assist DHH couriers in managing their orders during peak periods. This helps prevent an overload of orders beyond the capacity of the couriers, thereby reducing the risk of order delays. S3 added: *Around 12 am and 5 pm, I frequently reschedule orders for DHH couriers to prevent order delays.*

Some participants noted that the assistance of the station manager becomes critical when customers respond slowly to DHH couriers. For example, when a customer provides an unclear address, a DHH courier must contact the customer via text message to confirm the exact location. However, many customers do not respond promptly. In such cases, DHH couriers request the station manager call the customer for accurate information, which is then relayed back to the courier in text. This collaboration helps ensure the accurate delivery of orders. S2 stated,

> *"Though text can resolve issues, it can be time-consuming. Customers might not read messages, but a voice call can solve problems quickly. So, I always tell them to contact me directly when they face issues."*

Additionally, the station managers indicated that they often need to handle complaints from DHH couriers about negative ratings.

4.3 Challenges

4.3.1 Challenge of Greater Risks and Complexities.

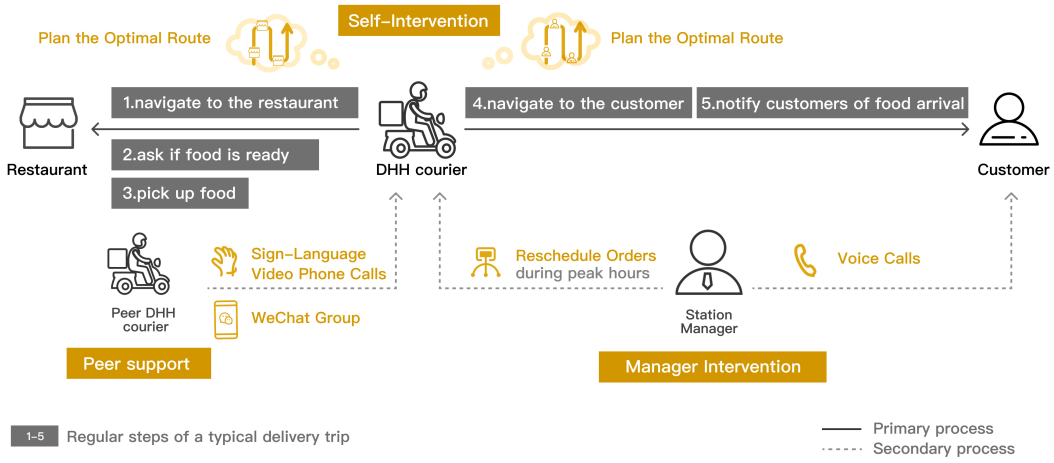

Fig. 4. The human intervention

(1) Higher Traffic Risks. Some participants mentioned that DHH couriers, due to their lack of sound awareness of the surrounding environment while riding, face higher safety risks compared to hearing couriers.

In our observational experiment, we noted that the non-motorized lanes used by couriers are relatively narrow and complex, with mopeds, bicycles, and pedestrians present. During the experiment, we observed that when mopeds behind needed to overtake, they often used their horns to alert the vehicle in front. In response, the experimenter would move closer to the edge of the lane upon hearing the horn, allowing the mopeds behind to pass. However, due to a lack of sound awareness, DHH couriers typically did not receive such auditory signals and did not move aside proactively. Even in conditions unfavorable for overtaking, mopeds would still forcefully pass by. After the observation, we conducted a brief interview regarding this situation. P1 expressed, *"I felt terrified because I was completely unaware of their presence. They were very close to me and moving at a high speed."* P3, who opts to work during off-peak hours, added,

> *"During the lunch and dinner order peak hours, there are many mopeds on the non-motorized lanes, and many couriers are in a hurry, moving at high speeds. There are frequent instances of overtaking. Since I can't hear the alerts, I choose not to work during peak hours."*

We found that the lack of sound awareness exposes DHH couriers to higher safety risks and leads to self-intervention in their work hours by some DHH couriers. They indicated that choosing to work during off-peak periods also reduces the number of orders and consequently lowers their wages.

(2) Complex Multitasking. We discovered that DHH couriers, while riding and delivering, need to perform multiple tasks simultaneously, including obtaining navigation routes, handling customer calls, receiving new order notifications, and paying constant attention to traffic conditions. Our participants mentioned that most hearing couriers typically wear Bluetooth headsets, enabling them to receive navigation and new order information through audio cues and take

customer calls while also being aware of alerts from vehicles behind them; however, for DHH couriers who cannot access information through sound, managing these multiple tasks concurrently while riding presents a challenge.

We observed that since DHH couriers cannot hear sound to receive information, some participants rely on visual means to access navigation details. At the same time, they face the concern of missing new orders. To avoid missing out, some DHH couriers operate their phones to refresh the order page while driving mopeds, worried that missing new orders could impact their income. They pointed out that using a phone while riding at high speeds heightens their hyper-vigilance, increasing their psychological burden and raising the risk of traffic accidents. P3 said,*"I check new orders about every two minutes because I fell twice last year because I was using my phone.*

Simultaneously, some DHH couriers emphasized that during riding, due to their inability to attend to customer notifications through auditory cues promptly, they often encounter communication problems because they do not check or promptly respond to customer messages. P4 has similar concerns,

> *"When communicating with customers via messages, I pay extra attention to their replies, even while riding. Delayed responses can lead to delivery problems. For instance, once a customer wanted to change the address, but I only realized it after making the delivery."*

The challenge of multitasking is not limited to when riding; DHH couriers also frequently need to switch between different platform features and built-in functions of their mobile phones during food pickup or delivery. This process is not only time-consuming but also increases the risk of errors. P4 said: *"During the peak order period, I not only have to pay attention to the remaining delivery time but also find electronic communication cards to communicate with merchants, which is a waste of time."*

4.3.2 *Challenges Related to Communication.*

(1) Distrust of AI Voice Calls. We found that although AI voice calls can efficiently help DHH couriers convey messages to customers, many customers often become suspicious of the AI voice and virtual phone numbers, associating them with potential telecom fraud. This frequently leads to customers hanging up the calls. In such cases, DHH couriers need to spend additional time explaining the situation to customers via text messages or seeking support from station managers.P5 stated,

> *"When customers hear the robotic voice, they often hang up, ignoring the accompanying messages. In such situations, I ask the stationmaster to assist in contacting the customer."*

Some participants mentioned that despite spending extra time informing customers about the arrival of their orders through text messages, some customers do not promptly notice these messages. This delay in receiving their orders can lead to customer dissatisfaction, with customers questioning why the couriers sent a text message instead of making a phone call. P4 elaborated,

> *"Some customers mistook the robotic voice for a scam call and hung up immediately. They later failed to collect their deliveries and filed complaints, claiming that I had not contacted them."*

Our participants highlight that AI voice calls are an effective mode of communication for most customers. However, this method is not as effective for particularly cautious customers and may even require more time to explain and convey information. Additionally, this can increase the communication pressure and frustration experienced by DHH couriers.

(2) Seeking Support. In the previous context, we mentioned that DHH couriers frequently need to seek support during their work. This primarily includes seeking help from station managers to resolve issues and assistance from community security guards or passersby during deliveries. However, our participants indicated that such frequent requests for support can impose a burden on both the station managers and DHH couriers. This could impact the recruitment of DHH couriers and their job satisfaction.

As mentioned in section 4.2.3, DHH couriers frequently require station manager intervention in their workflow. Some participants pointed out that while this can effectively assist DHH couriers, it also increases the workload for station managers.

Some station manager participants raised the point that, in addition to their workload increase, they also need to assume responsibility for risk management concerning DHH couriers, including managing safety risks and compliance risks. If a courier encounters an accident or makes a mistake, the station manager often bears some responsibility for managerial oversight, facing criticism or penalties. These additional management tasks further exacerbate the burden on station managers. S4, who manages three DHH couriers, said:

> *"While riding, DHH couriers also need to check messages, leading to two accidents last year. Hence, we're now very cautious when hiring DHH couriers due to the high safety risks involved."*

Some station managers believe that employing DHH couriers adds complexity and workload due to their lack of verbal communication and sound awareness abilities, leading to a higher risk of negative ratings and traffic hazards. Consequently, there is currently a cautious attitude towards recruiting DHH couriers.

In addition to seeking help from station managers, DHH couriers often need to ask passersby or security guards for assistance. This poses a challenge for those who are more introverted or reluctant to disclose their DHH status in public settings. Station manager S4 shared a DHH courier who quit within a month:

> *"He is too introverted, and does not like passers-by to know that he cannot speak, so he does not ask for directions, but finds himself, resulting in frequent order delays."*

Thus, we have found that some DHH couriers might experience psychological burdens when seeking support in public spaces, and simultaneously face higher risks of order delays.

(3) Sign Language Diversity. Chinese Sign Language is categorized into Standardized Sign Language and Natural Sign Language. There are differences in Natural Sign Language across various regions, with significant disparities between northern and southern China[7]. Despite efforts to promote standardized sign language nationwide, we found that most DHH participants primarily use Natural Sign Language, which has regional characteristics. Our participants mentioned that since sign language is the main form of communication among DHH couriers, the diversity in sign language can impact the interaction between couriers from different regions, particularly between those from the north and south.

Our participants echoed the characteristics of courier domestic migration mentioned in KALLE's study[25]. Among our six participants, five DHH couriers from Northern China chose to work in the more economically developed Southern cities[28]. P4 explained why he came to work in the South:

> *"I come from the rural areas in the north where the economy is underdeveloped, so I chose to come to the first-tier cities in the south. I heard that Hangzhou has a lot of demand for couriers, so I came here."*

Some DHH participants from the north expressed that although the south offers more employment opportunities and wages, the differences in sign language between regions pose significant challenges to communication among DHH people. They also mentioned that within the DHH courier community, there is a division between the Southern DHH

courier community and the Northern DHH courier community. DHH couriers from the north and the south primarily rely on written or typing communication to overcome the communication barriers caused by the differences in sign language. P1 said, *I can't understand the Southern sign language because I lived in the North. I communicate with southern DHH couriers in typing.*

Additionally, our participants added that variations in sign language can also affect peer support among DHH couriers. For instance, in the exchange of work experiences and assistance in solving work-related problems, differences in sign language may limit the transmission of information, thereby reducing the efficiency of problem-solving. Another northern courier P2 added,

> *"When I encounter problems at work, I seek help from northern DHH couriers even though the southern couriers are more experienced, but I can't read their expressions."*

4.3.3 Challenges for Dignified Means of Identify Disclosure. Identity disclosure is a significant work practice for DHH couriers. Although our participants expressed their willingness to disclose their DHH identity to customers through platforms and text messages among other ICTs tools, when DHH couriers are unable to rely on ICTs tools for identity disclosure, it may lead to uncomfortable experiences and lower job satisfaction.

Some DHH participants emphasized that effective use of ECC (Electronic communication card) or communicating through gestures with merchants is only possible when the merchant is visually aware of them. However, when the merchant is busy in the kitchen or facing away from the courier, they may not notice the DHH courier, rendering ECC or gesture communication ineffective. In such cases, some DHH couriers may resort to loud shouting or exaggerated actions to draw the merchant's attention to pick up the meals quickly. Our participants commented that this exaggerated form of self-disclosure in public places might cause DHH couriers to feel embarrassed and lose dignity, reducing their job satisfaction in courier work. P4 said,

> *"When the merchant was preparing the meal, I wanted to ask him how much longer it would take, but he had his back to me. I could only stamp my feet and scream to get his attention. It's an exaggeration, but I have to do it so I can get my food as quickly as possible."*

Some participants added that, in addition to causing discomfort for DHH couriers, these exaggerated behaviors also impact the dining experience of customers in the restaurant, leaving them feeling disturbed and perplexed. S4 shared an instance:

> *"Once, a restaurant merchant mentioned a DHH courier who repeatedly stomped his feet and made noises in the store. It was perplexing for the staff and disrupted the dining experience of other patrons."*

This situation occurs not only in restaurants but also when needing to enter gated communities. Participants mentioned that they require the help of security guards to open the gates, and these guards are often in a guardhouse located some distance from the gate. In such cases, hearing couriers usually communicate verbally with the guards to gain their attention and assistance. However, DHH couriers often shout loudly to attract the guards' attention to receive help. P3 said:*"When I'm pressed for time on an order, I frequently shout to get the doorman's attention. While this is effective, it feels a bit embarrassing to shout out on the road."*

5 DISCUSSION

5.1 Designing for More Inclusive Platforms

Our research responds to the characteristics of delivery work proposed by KALLE et al.'s study[25], specifically Real-time algorithmic management and Flexible scheduling. In our observational experiments, we found that food delivery platforms use algorithms to plan navigation routes between restaurants and customers, and DHH couriers rely on information provided by the platform to complete their deliveries. However, some DHH couriers indicated the need for self-intervention or assistance from built-in ICTs tools, suggesting shortcomings in the platform's current design for DHH courier needs. Interviews also revealed that, despite the platform offering identity disclosure tools, some DHH couriers still face awkward identity disclosure issues in their work. To address these issues and enhance the inclusivity of the delivery platforms, we identify some areas for improvement and offer some suggestions below.

5.1.1 Route Optimization for Merging Safety with Efficiency. P1 commented, "Delivering food is a race against time." As mentioned in Section 4.2.3(1), some DHH couriers follow system-planned routes, intentionally setting aside 1-2 minutes as a buffer to account for potential communication issues. However, the stringent time controls imposed by the platform sometimes drive DHH couriers to disregard traffic regulations to expedite deliveries. Coupled with their inability to pick up auditory danger cues, this can exacerbate risks. Furthermore, these platform route planning systems are designed to enhance delivery efficiency, planning the shortest possible routes. However, observations indicate that some DHH couriers plan their routes to avoid heavy traffic and complex road conditions or work during off-peak hours with less traffic (as mentioned in section 4.2.3 (1)). These situations suggest that the platform's current route-planning algorithms may not fully consider the needs of DHH couriers. Therefore, we recommend that in designing routing algorithms, platforms should balance efficiency with the safety of DHH couriers or involve DHH couriers in the design process at an early stage.

5.1.2 Enhancing DHH Disclosure with Dignity. Among our DHH participants, there's a prevalent tendency to disclose their DHH identity proactively. This deviates slightly from prior research on DHH Uber drivers as cited in [27]. In that study, certain DHH drivers opted to withhold their DHH status until after passengers boarded, driven by concerns that passengers might cancel rides upon discovering their condition. Contrarily, all our DHH participants observed that voluntarily revealing their DHH status often fosters enhanced understanding and patience from passengers.

The act of identity disclosure is fundamental to the daily duties of DHH couriers. While several platforms have instituted methods for DHH couriers to convey their status, there persist situations demanding overt physical gestures or vocalizations in public settings. Such situations can feel intrusive or even degrading, as the experiences of P3 and P4 vividly illustrate. It's incumbent upon these platforms to devise more inclusive and intuitive mechanisms that allow DHH couriers to announce their status, especially in situations where their condition might go unnoticed in public spaces.

5.2 Inclusive Assistive Technology for DHH Couriers

5.2.1 Trust in AI-mediated communication. AI can be an indispensable tool to bridge communication gaps, but only if that tool is perceived as trustworthy by customers. As mentioned in Section 4.5.2, many customers did not trust the robot voice and hung up the AI voice phone. This not only prevents customers from receiving timely information about their orders but also imposes additional tasks on DHH couriers, such as asking passersby to make calls to customers. Therefore, how to design better AI-mediated communication to enhance customer trust is worth considering.

A key challenge is the perception of AI as impersonal, yet certain methods may offer solutions. Research has demonstrated that a robot voice with humanlike perceptions sounds more natural and enhances audience engagement.[51]. Additionally, the use of machine voices with intonation resembling human voices may increase people's affinity for the voice.[23].

Beyond just AI sound modification, platforms should focus on designing more holistic communication strategies. These strategies should encompass more than just voice-based interactions, aiming to create an environment where DHH couriers can convey their messages effectively, ensuring customers feel respected and understood.

5.2.2 Sound Awareness. Environmental Sound Awareness In urban environments where couriers operate, auditory cues play a pivotal role in ensuring safety and efficiency. However, for DHH couriers, the lack of environmental sound awareness poses multifaceted challenges, as discussed in Section 4.3.1. It becomes vital to develop tools capable of capturing and interpreting these sounds in ways DHH couriers can readily understand. These systems can function collaboratively, with cues—whether their vibrations [20] [53] [15] or lights [11]acting as collaborators within the courier's environment, assisting in navigating potential hazards.

Furthermore, it's essential to be wary of the potential for cognitive overload in DHH couriers. Bombarding them with continuous haptic or visual feedback might increase their cognitive burden, diverting attention from their primary responsibilities and potentially compromising safety. Consequently, design considerations should emphasize filtering non-essential sounds and prioritizing critical alerts. When leveraging technology to augment environmental sound awareness for DHH couriers, striking the right balance between cognitive load and safety is paramount.

5.3 Designing for Inclusive Human Mediation in Digital Workflows

Human intervention plays a unique role in food delivery work, complementing and being complemented by ICTs. Our research responds to the study by Samantha Dalal and others, where stakeholders intervene in the delivery process in various ways. Couriers can enhance their efficiency through their own experience[17] and engage in strategic maneuvers with platform algorithms[52]. Peers also provide support by exchanging information and sharing experiences[17][32]. Managers' intervention plays a crucial role in the workflow. They can both identify couriers' rule violations through platform monitoring and notify them and also use platform data to identify order peaks and flexibly schedule courier orders[17][10].

At the same time, we also found that human intervention has a unique value for DHH couriers. P2 and S2 mention that DHH couriers reserve work time and choose work time slots based on their own experience to avoid order delays and safety risks caused by hard of hearing. In the interview with P4, it was mentioned that due to the different tools used by DHH couriers in their work compared to other couriers, they often need to seek DHH peer support in DHH couriers' WeChat groups. The station managers not only assist DHH couriers in scheduling orders but also help them communicate with customers during peak order periods. They communicate with customers via phone and send the results to DHH couriers in text form. This is valuable in promoting accessible communication for DHH couriers.

In summary, human intervention in the delivery process remains indispensable. We believe that in the future, more in-depth research is needed to develop a better delivery system. This system effectively integrates the human interventions of various stakeholders into the delivery service. For example, based on couriers' ability assessments, geographical locations, and other factors, it displays possible delays, allowing couriers to control their tasks better.

5.4 Empowering the DHH Workforce: Opportunities and Challenges

5.4.1 Technological Accessibility and Localization. Current delivery platforms are not inherently designed to cater to the needs of people with disabilities. While these platforms have developed assistive communication tools to alleviate communication barriers for the DHH, such as AI voice calls and Electronic communication cards, these tools may not fully meet the requirements of DHH couriers. They often have to switch between platform features and their phone's built-in functionalities, such as voice-to-text features, to address communication needs. This multitasking may pose additional challenges for DHH couriers. If platforms were to consider principles from accessibility research and integrate disabled individuals' perspectives from the initial design stages[19], it could provide a better user experience for both DHH couriers and customers[44]. From the outset, the goals and requirements of DHH couriers should be central to the design. For instance, platforms might offer a more integrated technological environment, allowing couriers to understand customer needs directly within the app when a customer calls. Potential solutions for scenarios when DHH couriers can't answer voice calls should also be considered. Furthermore, effective channels for consultation should be established to address communication difficulties and information disparities arising from differences in sign languages among DHH couriers. This proactive approach to platform development can contribute to a more inclusive and accessible experience[19].

5.4.2 Social-Cultural Dynamics and Livelihood. Disabilities in developing nations often confront societal prejudices[1], which tend to overshadow their potential and fixate on their disability. Given their inclination towards gig economies due to restricted employment prospects[41]. ICTs act as powerful tools for integrating disabilities into society[21][43]. Platforms bear a responsibility to harness and apply ICTs effectively, but many currently fall short in this area. For instance, it's essential to enable DHH couriers to disclose their status with dignity, mitigating societal stigmatization of the DHH community. Furthermore, establishing secure labor practices and inclusive, accessible designs is vital to both protect DHH couriers from exploitation and enhance their work experience.

6 LIMITATIONS AND FUTURE WORK

6.1 Limited Delivering Platforms

We delved into the experiences of DHH couriers primarily operating on Chinese delivery platforms such as Ele.me and Meituan. While our findings shed light on their challenges and interactions on these platforms, it's important to recognize potential variances across different delivery platforms. Although we expect our results to be broadly applicable to many delivery platforms, nuances in platform design, routing algorithms, customer interaction systems, or feedback mechanisms on other platforms might influence the experiences of couriers in ways that our study has not captured.

6.2 A Limited Coverage of the DHH groups

Our study primarily centers on male couriers and station managers from the Ele.me and Meituan platforms within the DHH community. While we made efforts to include female DHH participants, none were available. This absence means the challenges and perspectives unique to female DHH couriers remain unexplored in our study.

Furthermore, we observed a relatively narrow age range among our study participants, with DHH couriers primarily ranging from 24 to 35, while station managers were slightly older. This limited age distribution primarily reflects the age range of DHH couriers we encountered on the Ele.me and Meituan platforms rather than a lack of willingness to participate by younger or older DHH people. Consequently, our study might have yet to fully capture the experiences

and perspectives of DHH people across different age groups in the courier industry, potentially offering a limited view in exploring age-related challenges and adaptations. We hope to expand the age range of participants in our future work to gain a more comprehensive insight.

Additionally, our study delineated the experiences of individuals who identify themselves at a particular DHH state level, marked as "I" in our dataset. This could potentially overlook the nuanced experiences of those who are at different states of DHH, thereby missing out on a more rounded narrative that a more varied DHH classification could have brought to light.

In conclusion, while our study brings forth valuable insights into the lives of DHH couriers working on specific platforms, it does display a limited scope in terms of gender diversity, age range, and DHH classification depth. Future research should aim to broaden the demographic canvas to incorporate a more holistic view of the diverse experiences within the DHH groups in the courier industry.

7 CONCLUSION

Our qualitative research delves into the motivations and practices of DHH couriers in China, and the challenges they confront. Many choose this job for its better wages and low entry barriers, They employ assistive communication technology tools like AI voice calls and Voice-to-Text to inform customers of order status and understand customer needs, and rely on human intervention, like manager intervention, to aid in the communication process. Our study highlighted the need for a balanced human-tech synergy in their workflow. Despite these aids, challenges persist, including hyper-vigilance, multitasking issues, and lack of dignified identity disclosure. Based on these findings, We present design considerations for improving the accessibility of the platforms in the areas of inclusive assistive technology, inclusive human mediation, and social-cultural dynamics. This study sheds light on the unique practices and challenges confronting DHH couriers in China, offering valuable insights into the interplay between human intervention and ICTs.

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A CODE SYSTEM

This is the coding system according to which qualitative data from DHH couriers and station managers are coded.

(1) **Economic income**
   (a) Pay-per-delivery
   (b) Tip income

(2) Working mode
   (a) Physical demand
   (b) Flexible time

(3) Peer relationship
- (a) Sense of community
- (b) Exchange work experience
- (c) Mentor a novice

(4) Learning process
- (a) Watch the platform training video
- (b) Pass on work experience

(5) Self-disclosure
- (a) Platform provided DHH tag
- (b) Screaming or exaggerated body movements
- (c) Disclosure of hearing impairment status through technical features
- (d) Seek help from strangers and inform DHH couriers of their identity

(6) Career advice
- (a) Better career recommendations for DHH couriers
- (b) Reason for resignation
- (c) The courier's previous work

(7) Work attitude
- (a) A courier's attitude towards his work
- (b) The tone of voice in which couriers communicate
- (c) Specific working hours

(8) Order-taking issues
- (a) Excessive orders during peak periods and bad weather
- (b) Station managers dispatch multiple orders at the same time

(9) Order pick-up issues
- (a) Couriers attract attention
- (b) Merchants take too long to make meals

(10) Order delivery issues
- (a) Considering multiple information at the same time
- (b) Complicated roads, buildings

(11) transportation
- (a) Due to the distraction of information exchange
- (b) The traffic is heavy during rush hour
- (c) Traffic safety in bad weather
- (d) Audible warning in traffic could not be heard

(12) Ability performance
- (a) Order quantity
- (b) Customers evaluation
- (c) Working hours
- (d) Night shift

(13) Couriers recruitment and management
- (a) Couriers recruitment methods and conditions

(b) Couriers induction training
(c) Help couriers solve problems on a daily basis
(d) Delivery order scheduling
(e) Couriers wage management

(14) Communication

(a) Differences in sign language
(b) The station managers helps DHH couriers communicate with customers
(c) DHH couriers communicate with others through technical features
(d) Face-to-face communication

(15) station risk

(a) Violation risk
(b) Security risk
(c) Performance risk
(d) Emergency/special case handling

(16) Technical expectations

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