**Title:** Assistive Technology for Students with Visual Disability in Schools for the Blind in Delhi

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**Suraj Singh Senjam [1], Allen Foster [1], Covadonga Bascaran [1]**

1. International Centre for Eye Health, Department of Clinical Research London School of Hygiene and Tropical Medicine, Keppel St, Bloomsbury, London WC1E 7HT, United Kingdom

**Praveen Vashist [2], Vivek Gupta [2]**

2. Department of Community Ophthalmology, Dr. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences, New Delhi, India

**Address for correspondence**

Contact: Suraj Senjam, ORCID ID: https://orcid.org/0000-0001-8204-3669
International Centre for Eye Health, London School of Hygiene and Tropical Medicine, Keppel St, Bloomsbury, London WC1E 7HT, United Kingdom
Email ID: drsurajaiims@gmail.com

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**Title:**

**Assistive Technology for Students with Visual Disability in Schools for the Blind in Delhi**

**Background:** To understand the awareness and utilization of assistive technology in students at schools for the blind in Delhi.

**Methods:** A cross sectional study was conducted among 250 students selected randomly from 10 blind schools in Delhi. Binocular distance presenting and pinhole vision acuity were assessed using Snellen "E" chart and a multiple pinhole occluder. Students were also interviewed using a questionnaire about 42 assistive devices to understand their awareness and use.

**Results:** Male participants were 72.8%. Of the total, 27.6% students had best corrected visual acuity <6/18 to 1/60, and the rest had <1/60 vision. The awareness about tactile and sound-based technology was good among students: Braille books (98%), Braille slate and stylus (99.2%), handheld audio recorders (77.6%) and screen readers (77.2%). Good awareness was reported for abacus (88.8%), walking long canes (94.4%) and smart cane (89.6%), audible balls (96%), Braille chess (82.8%) and talking watch (98%). Among the students with <6/18 to 1/60 vision, the awareness of visual based technology ranged from 0.8% (typoscope) to 43.6% (video magnifiers). Braille technology was used for reading by 96.4% (books) and for writing by 96.8% (Braille slate and stylus) irrespective of visual status. Other devices were poorly used ranging from nil (typoscope) to 55% (screen readers). The use of math and science learning devices was poor (<20%). Walking canes were used by 59% of students whereas 87.2% students used audible ball for games.

**Conclusion:** The results showed that majority of students used tactile based technology irrespective of visual status.

**Keywords:** Assistive technology; awareness; utilization; visual disability; blind schools

## Introduction

An assistive product (or device) is any external product or equipment whose primary purpose is to improve individual's functioning and performance. Assistive technology includes the products and system, together with application of organized skills and knowledge in order to maintain and improve functioning of people , and thereby promote healthy living in their society [1].

There are more than one billion people with some degree of disability in the world who may need assistive technology to improve their functioning [2]. Only a small proportion have access to assistive technology [3]. To address the substantial gap between needs and demand, World Health Organization launched the Global Cooperation on Assistive Technology (WHO-GATE) in 2014 [4]. WHO-GATE aims to improve access to high quality, affordable assistive technology. In 2016, it released the Assistive Products List (APL) which consists of fifty assistive devices including sixteen devices for people with visual loss [5]. In addition to GATE initiative, improving access to assistive technology is a fundamental component of WHO Global Disability Action Plan 2014-21 [6].

People with visual loss require assistive devices for a wide range of their activities including daily living, education and employment [7], [8], [9]. These assistive technologies range from low technology devices such as a large print book to specialized computer software [10].

Visually impaired children and students may need assistive technology for education and learning, which has the potential to improve academic performance and learning capacity [11]. Studies have demonstrated that use of assistive technology enhances skills acquisition and performance, such as handwriting, motor skills, reading, visual attention and perception, and maths skills [12], [13], [14]. Studies also reported that cognitive benefits associated with assistive technology use include understanding of the cause–effect relationship, increased attention span, and problem solving ability [15], [16].

Assistive technology also helps students with visual impairment and blindness in accessing many non-academic related indoor and outdoor activities. Two comprehensive studies of assistive technology applications in schools found that assistive technology facilitated independence including development of autonomy, self-determination, enhanced social interaction, increased motivation and improve self-esteem [13],[17].

Therefore, it is important to obtain information on the availability and use of assistive technology in students with visual disabilities. The aim of this study is to understand the awareness and use of Assistive Technology in students at schools for the blind in Delhi.

## Methods

### Study design

A cross sectional study was conducted in 250 children and young adults 10 years of age and above, attending schools for the blind of Delhi in 2018. There were 23 schools for the blind in Delhi which we identified in detailed mapping done during initial planning of the study. We prepared a list of these schools along with the numbers of students enrolled. All these schools were residential in type. Of the 23 schools, eight were primary (class I to V) and 15 were secondary (Class I to XII). First, we purposively excluded the primary schools. From the 15 secondary schools, we chose the ten schools which had a greater number of students enrolled. Four of ten were co-educational and 5 were boys and one was girls only. Many students despite living in such residential schools were also attended integrated schools of nearby.

### Sampling technique

A list of students aged 10 years and above was obtained from each of the 10 schools. Each student was allotted a unique number, and then a list of random numbers was generated by computer. We interviewed between 20-30 students from each school.

### Study tools

A total of 42 assistive devices was listed which consisted of 13 visual based and 29 tactile or sound-based devices. The tools were categorized in seven domains as “Reading”, “Writing”, “Maths”, “Sciences”, “Games & sports”, “Mobility” and “Activities of Daily Living”, The proforma and questionnaire consisted of (a) the students’ profile and vision status; (b) questions about awareness of the device; (c) questions about use of the device. Depending on the answers further questions about “need” for a device and training in use of a device were

explored. A colour pictorial booklet of assistive devices was developed for use with the questionnaire for the students with some residual vision function.

**Training of the team**

The study team consisted of a community ophthalmologist (primary investigator, PI ), an optometrist, field investigator, two social workers, and one field attendant. The PI provided two days training to the team about the study, assistive devices and proforma and questionnaire. The questionnaire was piloted by the team in one of the excluded schools before use in the main study.

**Ethical consideration**

Ethical clearance from London School of Hygiene & Tropical Medicine London and All India Institute of Medical Sciences, New Delhi was obtained before the study. Permission to carry out the study was also taken from principal of each school for the blind. The patient information sheet, consent and assent were translated into local language. A written consent from students aged above 18 years was taken. Assent of the students aged less than 18 years was obtained from school teachers and principals.

**Vision assessment of the students**

A modified Snellen 'E' chart with two optotypes (6/18, 6/60) was used for distance binocular vision. Distance vision was tested in four 'directions, with correct answers in 3 out of 4 directions being taken as a positive result. The 6/60 optotype was used at 3 metres and 1 metre, if not seen at 6 metres. Students who could not see 1/60 were tested for light perception.

**Study definitions:**

**Visual loss categorisation**

We categorised the vision of students using the following definitions:

a) **Low vision to 1/60:** A student with binocular best corrected visual acuity (BCVA) less than <6/18 to 1/60. They are potential beneficiaries of ATs based on visual skills such as optical aids or large print books.

b) **Less than 1/60 blindness:** A student with binocular BCVA less than 1/60 to no light perception. They are potential beneficiaries of ATs based on visual substitution skills

**Assistive technology based on body sense used in learning**

a) **Visual based ATs (VAT) -:** based on visual skills**.** AT that could benefit students with binocular BCVA less than <6/18 to 1/60 e.g. large print books, magnifiers, typoscope etc.

b) **Tactile and sound ATs (TAT):** based on visual substitution skills. AT that could benefit students with binocular BCVA less than 1/60 to NLP, e.g. Braille books or key board, DAISY books, walking (long) cane etc. They can also be termed as haptic devices.

**Potential beneficiary groups (PBG)**

We classified the potential beneficiary groups of students for assistive devices as follows:

1. **PBG- 1**: Students with best corrected binocular vision 1/60 or better, who may benefit from VATs e.g. large print books, CCTV, typoscope etc.
2. **PBG- 2:** Students with best corrected binocular vision <1/60, who may benefit from TATs such as Braille, DAISY etc.

**Awareness:** Students who had heard of the assistive technology in question. All students in the study were used as the denominator irrespective of visual status. In this study we categorized the awareness as good (67+%), moderate (34-66%), poor (<33%).

**Access to use of AT:** The proportion students who could benefit from the devices and have used a particular device at least once. For visual based ATs e.g., large print books or

magnifiers the denominator was the number of students with low vision to 1/60. We categorized access as good (67+%), moderate (34-66%), poor (<33%).

**Data management and analysis**

The collected data was checked daily and entered in EpiData version 3.1 [18]. A login and password were created for data protection. Entered data were export to STATA version 13 for cleaning and analysis. Later editing was done in the EpiData for any error or missing values. A descriptive analysis was done in STATA 14 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP).

## Results

Of the 250 students from ten schools for the blind in Delhi, 182 (72.8%) were male. The mean age was 14.8 years (SD±2.5); range 10 - 23 years. Out of the total students, 44 (17.6%) attended integrated schools (table 1).

### Vision status of the students

Out of the total 250 students, 69 (27.6%) had binocular best corrected visual acuity (BCVA) between less than 6/18 to 1/60 and 181(72.4%) had binocular BCVA less than 1/60 up to no light perceptions (table 1). Only 14 (5.6%) of the students had spectacles for either near or distance vision.

### Awareness of assistive devices

### Reading

The majority of the 250 students, 245 (98%) knew about Braille reading book and 185 (74%) were aware of audio format devices. Only 54 (21.6% ) of students knew about low vision enhancing lamps, 40 (16% ) for reading stands, and 5 (2%) for one window typoscope. (table 2).

### Writing

Almost all students, 248 (99.2%) had heard of the Braille slate and stylus and 214 (85.6%) students were aware of the Braille typewriters, 194 (77.6%) handheld audio recorders and 193 (77.2%) screen readers e.g. JAWS, NVDA etc. Among the least-known devices by students were the handheld pen magnifier 4(1.6%) and multiple window typoscope 2 (0.8%), (table 2).

### Mathematics

Eight assistive devices were included in the AT questionnaire for mathematics. Among devices with good awareness amongst the students were Abacus (220, 88%) and the talking calculator (147, 58.8%), whereas moderate awareness was reported for tactile geometric kits (90, 36%), and poor awareness for the Braille ruler (49, 19.6%). Only a few students were aware of the remaining assistive devices i.e. Braille compass (39,15.6%), Braille cube (27,10.8%), Raised line graph (20,8%), and Braille protractor (16,6.4%).

**Sciences**

Two assistive devices were included in the tool for science. Only 62 (24.8%) students had heard of tactile diagram sets for sciences such as animal or human anatomy e.g. heart, kidney etc. Tactile maps e.g. Earth and countries were known by 102 (40.8%) students.

**Mobility**

Two of the six orientation and mobility devices were known to the majority of students, 236 (94.4%) for walking or long canes, and 224 (89.6%) for smart canes. More than half of students 138 (55.2%) were aware of mobile navigation apps. Only 55 (22.0%) students had heard of children's canes, similarly, 12 (4.8%) for guide canes and 7 (2.8%) for symbol canes.

**Games and Leisure**

Five different assistive devices were included in the games and leisure questionnaire. Most of the students , 241 (96% ), were aware of the audible balls e.g. cricket, 207 (82.8%) for Braille chess and 149 (59.6%) for tactile dice. However, large print playing cards and Braille cards were heard of by 55 (22%) and 84 (33.6%) students respectively.

**Activities Daily Living (ADL)**

Only four devices were explored with regard to ADL. The majority of the students 245 (98%) were aware of the talking watch, whereas 173 (69.2%) of them had heard about the simplified

mobile phone for visually impaired students. Only 19 (7.6%) and 32 (12.8%) students responded that they were aware of the colour detector and liquid sensor.

**Use of assistive devices**

Students were categorized as having never used, occasionally used, or regularly used for an assisting device. In estimating the proportion of utilization for visual based ATs (VAT) e.g. large print books, magnifiers etc., we excluded students with <1/60 blindness who would not get any benefits from such devices. The potential number of beneficiaries for visual ATs was 69 children. For the proportion of utilization of haptic or tactile and sound-based devices, (TATs) we included all the students (250) i.e. BCVA <6/18-1/60 and <1/60 or less students e.g. Braille texts, embossed maps etc, as both groups can potentially benefit from their use.

**Reading**

Braille reading books were the device used by 241 students of the 250 (96.4%) as a medium for reading with a regular use by 227 students (90.8%). Seventy (28.0 %) students used Audio Format devices e.g. DAISY books (table 2), but only 41 students of total 250 students (16.4%) used it regularly.

Large print books were used at least once or regularly by 17 (24.6%) students with 1/60 or better vision; 13 of the 69 students (18.8%) for optical magnifiers, 17 of the 69 (10.1%) for reading stands and 4 (5.8%) for low vision enhancing lamps. Electronic magnifiers such as video magnifiers or CCTV were used occasionally by 5 (7.2%) students.

**Writing**

Almost all the students, 242 of the 250 students, (96.8%) used Braille slate and stylus with 222 (88.8%) reporting regular use with 139 of the 250 students (55.6%) using screen readers such as NVDA, JAWS for the purpose of writing. Similarly, 101 (40.4%) of students used a Braille typewriter but only 16 of the 250 students (6.4%) used it regularly. Nearly30% of

students used handheld digital audio recorders in the class room while listening to teachers' lectures instead of writing notes. Around 20% of students used large print computer key board whereas, very few students 13 (5.2%) used a Braille key board.

**Mathematics**

Of the 250 students, 149 (59.6%) used an abacus for maths learning. The talking calculator was used by 52 (20.8%) of the students but only 12 of the 250 students (4.8%) used it regularly. Tactile geometric kits were used by 35 (14%) students with regular use reported by 7 (2.8%).

Other assistive devices like the Braille ruler were used by 18 (7.2%), the Braille compass by 2 (3.2%), the Braille protractor by 7 (2.8%) and with occasional used of raised line graphs by 6 (2.4%) students.

**Sciences**

The two assistive devices for learning sciences were used by 46 (18.4%) students for tactile maps and 25 (10%) students for tactile or embossed diagrams such as heart or kidney.

**Mobility**

A total of 147 of the 250 students (58.8%) used walking long canes for mobility, 29.6% (74/250) reporting regular use. Very few students used children's walking canes 9 (3.6%). In a similar way, 116 (46.4%) students used smart canes, 57 (22.8%) of the total students being regular users. Around 14% students used mobile navigation apps for orientation and mobility. Less than 1% of them used either guide or symbol canes.

**Games and Leisure**

Of the 250 students, 218 students (87.2%), played with some form of audible balls (table 2). Tactile dice was used by 91 (36.4%) for games and leisure activities and Braille chess by 143

(57.2%). Less than a quarter of students used Braille cards 32 (12.8%) and large print playing cards 17 of the 69 students (24.6%).

**Devices for Activities of Daily Living (ADL)**

Four devices were assessed for ADL. Out of the 250 students, , 83 (33.2%) used a talking watch and 69 (27.6%) used a simplified mobile phone regularly. The liquid detector and colour detector were only used by 6 (2.4%) and 1 (0.4%) students.

**Table 1: Characteristics of participants (N=250)**

| Characteristic | | n | Percentage |
|---|---|---|---|
| **Organization of the school** | Govt. aided | 121 | 48.4 |
| | NGOs | 129 | 51.6 |
| **Gender** | Male | 181 | 72.4 |
| | Female | 69 | 27.6 |
| **Age** | 10-14 | 111 | 44.4 |
| | 15-19 | 133 | 53.2 |
| | 19+ | 6 | 2.4 |
| **Attended school** | Residential school (blind) | 206 | 82.4 |
| | Integrated school | 44 | 17.6 |
| **Class** | Primary (I-V) | 69 | 27.6 |
| | Middle (VI-VIII) | 91 | 36.4 |
| | Higher (IX-X) | 41 | 16.4 |
| | Secondary (XI-XII) | 49 | 19.6 |
| **Distance glasses** | Yes | 13 | 5.2 |
| | No | 237 | 94.8 |
| **Near glasses** | Yes | 14 | 5.6 |
| | No | 236 | 94.4 |
| **Vision status** | | | |
| **Low vision to 1/60** | <6/18-6/60 | 27 | 10.8 |
| | <6/60-3/60 | 17 | 6.8 |
| | <3/60-1/60 | 25 | 10.0 |
| **<1/60 blindness** | Light Perception (+)ve | 93 | 37.2 |
| | Light Perception (-)ve | 88 | 35.2 |

**Table 2: Awareness and Use of ATs in 250 students in schools for the blind in Delhi.**

| Type of Assistive Technology * | Have you heard of it? | | Awareness | Do you use it? | | | Total users | AT Potential beneficiaries(n) ** | Use |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | (%) | Never | Occasionally | Regularly | | | (%) |
| **1. READING** | | | | | | | | | |
| 1.1. Large print book | 176 | 74 | 29.6 | 57 | 13 | 4 | 17 | 69 | 24.6 |
| 1.2. Reading stands | 210 | 40 | 16.0 | 33 | 6 | 1 | 7 | 69 | 10.1 |
| 1.3. Optical magnifier (near) | 151 | 99 | 39.6 | 86 | 13 | 0 | 13 | 69 | 18.8 |
| 1.4. Optical magnifier Distance) | 192 | 58 | 23.2 | 54 | 4 | 0 | 4 | 69 | 5.8 |
| 1.5. Typoscope (one window) | 245 | 5 | 2.0 | 5 | 0 | 0 | 0 | 69 | 0.0 |
| 1.6. Low vision lamps (enhance lighting lamps) | 196 | 54 | 21.6 | 50 | 3 | 1 | 4 | 69 | 5.8 |
| 1.7. Braille reading books | 5 | 245 | 98.0 | 4 | 14 | 227 | 241 | 250 | 96.4 |
| 1.8. Electronic Magnifiers Aids (video magnifiers, CCTV) | 141 | 109 | 43.6 | 104 | 5 | 0 | 5 | 69 | 7.2 |
| 1.9. Audio format materials (DAISY) | 65 | 185 | 74.0 | 115 | 29 | 41 | 70 | 250 | 28.0 |
| **2. WRITING** | | | | | | | | | |

| Type of Assistive Technology * | Have you heard of it? | | Awareness (%) | Do you use it? | | | Total users | AT Potential beneficiaries(n) ** | Use (%) |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | | Never | Occasionally | Regularly | | | |
| 2.1. Braille slate and stylus | 2 | 248 | 99.2 | 6 | 20 | 222 | 242 | 250 | 96.8 |
| 2.2. Braille typewriter | 36 | 214 | 85.6 | 113 | 85 | 16 | 101 | 250 | 40.4 |
| 2.3. Typoscope (multiple window) | 248 | 2 | 0.8 | 2 | 0 | 0 | 0 | 69 | 0.0 |
| 2.4. Large computer keyboard | 204 | 46 | 18.4 | 33 | 8 | 5 | 13 | 69 | 18.8 |
| 2.5. Braille keyboard | 183 | 67 | 26.8 | 54 | 11 | 2 | 13 | 250 | 5.2 |
| 2.6. Handheld pen magnifiers | 246 | 4 | 1.6 | 3 | 1 | 0 | 1 | 69 | 1.5 |
| 2.7. Handheld audio recorder | 56 | 194 | 77.6 | 81 | 41 | 72 | 113 | 250 | 45.2 |
| 2.8. Screen readers (JAWS, NVDA) | 57 | 193 | 77.2 | 54 | 40 | 99 | 139 | 250 | 55.6 |
| **3. MATHEMATICS** | | | | | | | | | |
| 3.1. Abacus | 30 | 220 | 88.0 | 71 | 124 | 25 | 149 | 250 | 59.6 |
| 3.2. Braille compass | 211 | 39 | 15.6 | 31 | 6 | 2 | 8 | 250 | 3.2 |
| 3.3. Talking calculator | 103 | 147 | 58.8 | 95 | 40 | 12 | 52 | 250 | 20.8 |
| 3.4. Braille ruler | 201 | 49 | 19.6 | 31 | 14 | 4 | 18 | 250 | 7.2 |

| Type of Assistive Technology * | Have you heard of it? | | Awareness (%) | Do you use it? | | | Total users | AT Potential beneficiaries(n) ** | Use (%) |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | | Never | Occasionally | Regularly | | | |
| 3.5. Braille protractor | 234 | 16 | 6.4 | 9 | 6 | 1 | 7 | 250 | 2.8 |
| 3.6. Raised line graph | 230 | 20 | 8.0 | 14 | 6 | 0 | 6 | 250 | 2.4 |
| 3.7. Tactile geometric kits | 160 | 90 | 36.0 | 55 | 28 | 7 | 35 | 250 | 14.0 |
| 3.8. Braille cube | 223 | 27 | 10.8 | 14 | 10 | 3 | 13 | 250 | 5.2 |
| **4. SCIENCES** | | | | | | | | | |
| 4.1. Tactile maps | 148 | 102 | 40.8 | 56 | 39 | 7 | 46 | 250 | 18.4 |
| 4.2. Sciences tactile diagram set (e.g. Heart, kidney etc) | 188 | 62 | 24.8 | 37 | 18 | 7 | 25 | 250 | 10.0 |
| **5. MOBILITY** | | | | | | | | | |
| 5.1. Walking (long) canes | 14 | 236 | 94.4 | 89 | 73 | 74 | 147 | 250 | 58.8 |
| 5.2. Children's canes (60- 85 cm) | 195 | 55 | 22.0 | 46 | 8 | 1 | 9 | 250 | 3.6 |
| 5.3. Guide canes | 238 | 12 | 4.8 | 10 | 1 | 1 | 2 | 69 | 2.9 |
| 5.4. Smart canes | 26 | 224 | 89.6 | 108 | 59 | 57 | 116 | 250 | 46.4 |
| 5.5. Symbol canes | 243 | 7 | 2.8 | 6 | 0 | 1 | 1 | 69 | 1.5 |

| Type of Assistive Technology * | Have you heard of it? | | Awareness | Do you use it? | | | Total users | AT Potential beneficiaries(n) ** | Use |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | (%) | Never | Occasionally | Regularly | | | (%) |
| 5.6. Mobile apps (GPS) | 112 | 138 | 55.2 | 103 | 20 | 15 | 35 | 250 | 14.0 |
| **6. GAMES AND LEISURE** | | | | | | | | | |
| 6.1. Tactile dice | 101 | 149 | 59.6 | 58 | 50 | 41 | 91 | 250 | 36.4 |
| 6.2. Large print play cards | 195 | 55 | 22.0 | 38 | 16 | 1 | 17 | 69 | 24.6 |
| 6.3. Large print with Braille cards | 166 | 84 | 33.6 | 52 | 21 | 11 | 32 | 250 | 12.8 |
| 6.4. Braille chess | 43 | 207 | 82.8 | 64 | 69 | 74 | 143 | 250 | 57.2 |
| 6.5. Audible games balls (e.g. cricket, simple balls) | 9 | 241 | 96.4 | 23 | 43 | 175 | 218 | 250 | 87.2 |
| **7. DAILY LIVING EQUIPMENT** | | | | | | | | | |
| 7.1. Liquid sensor | 218 | 32 | 12.8 | 26 | 6 | 0 | 6 | 250 | 2.4 |
| 7.2. Colour detector | 231 | 19 | 7.6 | 18 | 1 | 0 | 1 | 250 | 0.4 |
| 7.3. Simplified mobile phone | 77 | 173 | 69.2 | 40 | 64 | 69 | 133 | 250 | 53.2 |
| 7.4. Talking watch | 5 | 245 | 98.0 | 35 | 127 | 83 | 210 | 250 | 84.0 |

*Visual based ATs (VAT): (<6/18-1/60)=1.1 to 1.6, 1.8, 2.3, 2.4, 2.6, 5.3, 5.5, 6.2. Red highlighted

**n=69: Potential beneficiaries of assistive devices of VAT; n=250: all students irrespective of their visual status

## Discussion

Assistive technology is a relatively new concept as discussed by Pintor et al [19]. AT is primarily developed and designed to improve the functional capabilities of the people with disabilities including visual disability. As a result of WHO World Disability Report published in 2011,[2] assistive technology is gaining importance. The recently concluded WHO GREAT summit 2017 has identified five main research themes on assistive technology; [20] of which assessment of awareness, and the use of AT were included. Further, the WHO Rehabilitation 2030: A Call for Action, states that a comprehensive and quality rehabilitation service including equitable access to assistive products is one of ten areas for action [21]. In the context of eye health, one important key function of Universal Eye Health Coverage is the provision of rehabilitative care along with assistive devices for people with living with blindness or visual loss.

Blindness is a severe disability affecting educational activities significantly.[22] Studies from developing countries report a literacy rate among blind and visual impairment being less than 3% [23], [24]. It is critical to ensure that children with visual disabilities attend school and enjoy educational activities. These students need to learn to use technologies based on the senses of touching, hearing or vibration, ATs are important to improve the educational performance beyond the use of conventional magnifiers.

There are a number of studies exploring the need for rehabilitation services in students in schools for the blind but are limited to optical and low vision services [25], [26],[27],[28]. The present study explores the awareness and use of ATs by children with blindness and visual impairment in 10 schools for the blind in Delhi. To the best our knowledge, this study is first of its kind conducted in India.

### Definition for low vision, functional low vision (FLV) and blindness of WHO

We did not categorise students according to WHO definitions of visual impairment, that is low vision ((<6/18 to 3/60) and blindness(<3/60 up to NLP), nor did we use functional low vision (<6/18 up to PL+), while estimating the utilization rate of ATs for students [29]. Using WHO definition can be misleading if for example, a student with a vision acuity (<3/60 - blind) may still be able use ATs such as large print books, magnifiers, typoscope etc to read print. Similarly, FLV includes perception of light (BCVA <6/18 up to light perception) at which level students may need braille to read. Therefore, we used a definition with a cut-off

at best corrected binocular visual acuity (BCBVA) 1/60. Choosing this cut-off was based on previous work by Silver et al. showing that 1/60 is the best cut off to determine which children should substitute the visual skills by other form of non-visual aids such as haptic or sound devices [26].

**Classification of assistive technology for students with visual disability**

In our study, we classified assistive technology for children's education activities into seven different categories (table 2). Austin et al. described ATs for visually disabled into four categories, [30] however, we also included mobility, games & leisure and ADL in our assessment since they are a part of student activities and life in school. We also categorized ATs based on the body sense being used in learning, that is 'visual skills' (VAT); and tactile & sound based AT.

**Awareness and utilization of VATs among PB group 1 (n=69)**

The present study showed that the utilization rate of VATs among PBG-1 (<6/18 to 1/60) was poor, with only 24.6% of students using large print books, 10.1% reading stands, 19% near optical magnifiers, 7.2% electronic magnifiers and 2.9% guide canes etc.

**Awareness and utilization for TATs among all students (N=250)**

On the other hand, the awareness and utilization of some TATs was high. Braille reading books were known by 98% with regular use by 96.4% students (table 2). Similarly, TATs for writing, Braille slate and stylus awareness were known by 99% and used by 98% of students. This included students in PBG-1 who are likely to be able to read print with VATs. The majority of PBG1 (<6/18 to 1/60) who would benefit from VATs did not have access or use to them. Therefore, these students learned Braille for reading as well as writing. This highlights that Braille is the primary medium of reading as well as writing in these students irrespective of their visual status. The east Africa study in schools for the blind on need for low vision services reported that nearly 60% of students who would benefit from low vision devices were being taught Braille instead [26].

A study in India reported that the most difficult activities faced by low vision students in the classroom were copying from blackboard (80%), reading text book (77%) and writing along

a straight line (77%) [31]. These activities would certainly improve if the relevant and appropriate ATs were made available to them like a distance magnifier or audio recorder for the lectures, large print books for reading or typoscope for writing in straight line.

The probable reasons for using tactile based ATs (TAT) instead of visual based ATs (VAT) in students with at least 1/60 vision could be as follows:

1. Braille books and slate & stylus are widely available and relatively cheaper than other technologies.
2. Compared to Braille, other VATs are not widely available in these schools for the blind.
3. Teachers were reluctant to change the medium of teaching.
4. When teachers were asked, most of them responded that learning Braille at an early period was good as it helped students in future if their vision deteriorated.

However, a further study is warranted to assess the appropriate reasons. A population-based study on awareness and barriers to adoption of computer assisted assistive technologies e.g. screen readers etc. in the age group 20 to 59 years in Nigeria highlighted that the awareness of devices was associated with the amount of years of visual impairment [32].

**ATs for Mathematics and Sciences**

Everyone irrespective of visual status needs some level of mathematics and science skills and knowledge which will help to improve their cognitive skills, their physical health & hygiene and their quality of life [33]. This study showed that there was minimal access to mathematics and science ATs.

**Orientation & Mobility (O&M)**

Two of six ATs for O&M i.e. long walking cane and smart cane, showed good awareness (67+ %) and moderate utilization rate (33-67%). However, many students did not recognize the name of the other canes (guide and symbol cane) which are mainly designed for children with low vision. The reason could be that students were not sure of the different terminology of each cane. This may reflect the lack of training on AT for mobility. This is a matter of concern as mobility is the foremost priority for these students.

In the study, it was also shown that for many assistive technologies, the awareness was reasonably high, but utilization was poor e.g. electronic magnifiers like CCTV: 44% aware but used by 7.2%, DAISY books; 74% aware, but used by 28%. One reason is the financial limitation in purchasing these devices.

There are limitations to our study. We could not cover all schools for the blind in Delhi due to limited time and resources. Despite being of residential, it is possible that some students from Delhi attended the school during the day and went back home after school hours. For such students, there might be parental influences on awareness and usage of devices. Though, we were not able to gather information on this, we believe out of the total sample, it will be a small number. The study did not investigate the cause of poor vision though aetiology of visual impairment is important for visual prognosis as well as in adoption of assistive technology. Further study is warranted to know the aetiology of visual impairment that influences the use of assistive technology. Some devices might not be of benefit to the students despite being categorised as potential beneficiaries. This might affect the estimation of usage rate. The study is limited to schools for the blind in Delhi which may not be representative of India as a whole, however findings from Delhi are not likely to be better in poorer and rural areas of India.

## Conclusion

The results showed that the majority of students in schools for the blind in Delhi, irrespective of their visual loss, used tactile and sound based ATs despite the fact that those with some residual vision (1/60 or Better) may benefit from visual based ATs. The reasons for this are likely to be lack of awareness and training in teachers and students and financial constraints for more expensive ATs. The study has shown that there is minimal access to ATs for Math and Sciences. It also revealed that the majority of children were not sure about the terminology of the various mobility canes.

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**Declaration of interest**

The authors report no conflicts of interest.

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