Bone conduction hearing kit for children with glue ear

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INTRODUCTION
Background
Hearing loss is one of the most common disabilities in childhood.1 One in 10 children starting school in the UK or Europe have hearing loss secondary to glue ear (Otitis Media with Effusion (OME)).1,2 This is much higher in lower income countries. Eighty per cent of children have at least one episode of glue ear, where fluid builds up behind their eardrum after a cough, cold or ear infection. OME often self-resolves or children can be offered grommets (also known as ‘tymanostomy tubes’) if persistent.3 Grommets ‘only offer short term hearing improvement’4 of ~12 dB, diminishing to ~4 dB 6–9 months later, therefore grommets improve a child’s symptoms for about 6 months while ‘natural resolution continues’.3 Grommet insertion is common, requiring a general anaesthetic, and risks include opening the middle ear to infection (requiring treatment in approximately a third of cases), perforation (1% of cases) and variable scarring the eardrum (tympanosclerosis).

Hearing aids are not an easy solution, since glue ear fluctuates and multiple audiology appointments are needed to avoid overamplification or underamplification. Children need to hear to learn. Poor hearing can affect speech, language, social skills, listening, attention and learning. While some children catch up learning after an episode of glue ear, others do not. Glue ear mostly affects those under 8 years old, which is a critical time for development, speech acquisition, learning, writing, spelling and phonics.5 Deafness at this time interferes with speech development, language, communication, auditory processing, self-esteem, socialisation, listening and learning.5

Summary box
What are the new findings?
► Cheap alternatives to hearing aids can be used for children with glue ear.
► Care for glue ear can be delivered remotely.
► The kit (Bone conduction (BC) headphones, microphone and Hear Glue Ear app) is acceptable to children and their families.

How might it impact on healthcare in the future?
► Further clinical trials could evidence cost-effectiveness and clinical effectiveness of the solution.
► Grommets may be able to be avoided in many cases of glue ear.
► Mild, fluctuating cases of glue ear could be offered early hearing support.
► Schools may need further sensory support training to assist children in the classroom situation.

Operational aims and objectives
Bone conduction hearing aids work well in OME because they send sound as a vibration through the bones of the skull directly to the cochlea (by-passing the eardrum and middle ear bones where the fluid, mucus or ‘glue’ accumulates) but they are often prohibitively expensive, costing up to £3000. Bone conduction headphones are marketed at cyclists, allowing sound from mobile phones to be directed straight to the cochlea while sound from traffic noises still accessible through the ear canals. These headphones cost ~£100 commercially (figure 1). An initial study in 2016–2018 trialled these simple bone conduction headphones paired to a microphone for the first time in children with OME.6

The Hear Glue Ear app was trialled in 2019.7 It was codesigned with a patient
and public voice group. Parents wanted to support their children over the watchful waiting period, prevent their child from falling behind and wanted trusted information about other aspects of glue ear (tinnitus, auditory processing difficulties, speech and language, education, balance, etc). They also needed a way to estimate their children’s hearing at home, as well as speech and language enrichment for their child. The app was CE (‘Conformité Européenne’: Conforms to European safety and health requirements) marked as a class 1 medical device, awarded an ORCHA (Organisation for the Review of Care and Health Apps) approval badge and won several awards. The Raspberry Pi Trading Limited has a product set (Bone Conduction (BC) headset and microphone kit) to be widely available at the end of 2021 for ~£55. The Hear Glue Ear app (figure 2) is currently free and on Apple and Android app stores.

A trial was conceived to test whether sending BC headphones, microphone (the kit) and details of the free Hear Glue Ear app to families for self-management with remote support would be an acceptable way to manage OME. Online supplemental appendix 1 shows the instructions sent to parents.

METHODS

During the first wave of the 2020 COVID-19 pandemic in the UK children’s audiology services and grommet operations were completely stopped. Children diagnosed with OME (hearing worse than 25 dB at two or more frequencies in at least one ear) and those on a grommet operation list were invited to enrol in a single arm, a prospective study assessing the use of bone conduction headset, wireless Bluetooth microphone ‘the kit’ and Hear Glue Ear app from July 2020. It was not possible to recruit a control group while there was no standard of care during the pandemic.

Participants were posted the kit for use at home and school with instructions for the headset and details of the Hear Glue Ear app. The parents were told to follow instructions and asked to self-check the headset volume (if the parent had normal hearing) to a comfortable level before handing it to their child.

Within the first 3 weeks, parents answered questions about their child’s hearing by completing a standardised OMQ-14 questionnaire (Otitis Media Quality of life questionnaire to assess impact of ear problems in children) with and without the kit. Follow-up consultations were remote, by video or telephone over 3 months. A website (www.hearglueear.wordpress.com), initially made solely for research participants, communicated study details, results and publications.

RESULTS

Study population

Twenty-six children between 3 and 11 years (average age 5 years) were enrolled, which was 82% of children on the local grommet (tympanostomy tubes) operation list. Before lockdown in March 2020, the average (mean) hearing loss in the group was a mild hearing loss at frequencies of 0.5, 1, 2 and 4 kHz ranging from 0 to 65 dB.

Kit set-up

Twenty-three out of 26 parents reported that the child ‘often’ or ‘always’ had difficulty hearing in a group before the intervention, compared with 22 out

Parent’s reported perception of their child’s hearing

In the 3 months before the kit was supplied, 19 out of 26 parents reported their child’s hearing as poor or very poor. One parent was unsure. With the kit in use, no parents reported hearing as poor or very poor and 24 out of 26 reported it as ‘normal’ or ‘slightly below normal’ (figure 3). Two parents were unsure.

Twenty-three out of 26 parents reported that the child ‘often’ or ‘always’ had difficulty hearing in a group before the intervention, compared with 22 out
Usage of kit at schools

Fifty-eight per cent (15) took the kit to school or nursery. One wanted to take the kit to school but parents advised against it. One teacher said she ‘would see’ if the child needed it in class so the child continued to use it at home.

One family who could use the kit at home found the teacher struggled to pair it at school. Families used the teacher information sheet when taking the kit to school. One family commented the school took their child’s hearing more seriously as a result of the need for the headset: one parent commented the headset was a visual cue to others their child needed support. Three parents mentioned schools needed more support, or more resources, to use the kit at school.

Three parents contacted their school’s special educational needs coordinator and two teachers addressed the class about the headsets: this helped children use the kit seamlessly at school and helped discuss their hearing with their peers: one child checked daily that the kit had been charged overnight and placed the kit back in his school bag.

Outcomes at end of study

At the end of the study, families were able to keep the kit and contact the team if they had questions or concerns in line with ethical approval. All families chose to keep the kit at the end of the study, even if the child’s hearing improved, often hearing glue ear may return with the child’s next cough, cold or ear infection, as ‘lockdown’ was lifted. No child had a grommet operation by December 2020 (9 months after lockdown). Three families said they would continue to use the kit rather than have a grommet operation. Three children’s glue ear fully resolved while they were using the kit. The majority of families found the remote management strategy acceptable and thought their child had benefited.

**DISCUSSION**

Remote management of glue ear in this way has many advantages: improving children’s hearing at an important stage of their development; preventing sequelae of hearing loss; preserving face-to-face hospital appointments with surgeons and audioligists for those needing them most; reducing travel to clinics with small children; empowering the parents/carers to support their children; enabling children to hear online learning more clearly; enabling children to hear when face masks obscured lip reading; cost savings for the National Health Service (NHS) from cost-effective hearing support and reduction in the number of grommet operations.

Importantly, the parents’ comments showed their children benefited from the kit, helping them hear better at home and school, and in some cases improved their pronunciation, behaviour and listening anxiety.

One family who could use the kit at home found the teacher struggled to pair it at school. The wide variation in support and acceptability in use of the kit at school suggests that the teacher’s instructions need to be more comprehensive and teacher-of-the-deaf (TOD) support may be needed in this setting.

Limitations of the study included that it was short term, non-randomised and could only recruit a small number of children.

**CONCLUSIONS**

Innovative use of bone conduction headphones, a microphone and the Hear Glue Ear app, sent through the post to patients, is a novel, new and effective approach to the management of glue ear and its resulting hearing loss, especially when families have reduced access to audiology or Ear Nose and Throat (ENT) services such as during the COVID-19 pandemic. The hearing screen on the Hear Glue Ear app allows families to monitor their child’s hearing at home and use the kit as needed. Fewer grommet insertions were required by
the end of the study. Families found this was an acceptable and positive management strategy.

Further research should be targeted at the scaling of this intervention—detailed economic analysis including the cost of grommets and clinic visits, randomised trials to compare with standard treatment and rigorous qualitative analysis of the key issues and themes for children, families, their parents and teachers.

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Collaborators Expert Otolaryngology and Audiology Collaborators: Josephine Marriage, Roger Gray.

Contributors TMHB: conceptualisation, data curation, seeking donation of equipment for study, methodology, investigation, visualisation, writing original draft, review and editing, literature search, figures, study design, data collection, data analysis, data interpretation, writing. IFO'C: methodology, recruitment, investigation, manuscript study design, review of drafts and editing. JB: methodology, recruitment, data curation, manuscript study design, data interpretation, helped verify underlying data, review and editing of drafts. CM: conceptualisation, data curation, manuscript supervision, verified underlying data, manuscript figures, data analysis, data interpretation, writing, review and extensive editing.

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REFERENCES

Appendix 1. Instructions for parents and teachers

Hear Glue Ear Assistive Hearing Set for children: Instructions for Use

What is the Hear Glue Ear assistive hearing set?

This set comprises two devices: a bone conduction headset, and a microphone. There is a video about setting up this product on website www.hearglueear.wordpress.com the ‘menu’ has an option at the bottom called “Research during covid-19” which has all the information about this study and videos for use.

The headset uses vibrations to enable your child to hear sound better. The vibrations go through their cheek bone and into their inner ear, avoiding the middle ear. This will assist your child to hear more clearly if they have a conductive hearing loss.

The microphone is used to transmit sound to the headset.

The headset can also be used like a set of normal headphones when paired with a mobile device (such as a tablet or mobile phone) to allow your child to hear high quality sounds when watching programmes, listening to audiobooks or playing games which are all available on the free Hear Glue Ear app which we would like you to download from the App Store.

For reassurance the Hear Glue Ear app is registered as a class 1 medical device and has been approved and recommended by professional audiology and medical bodies such as the, Organisation for the Review of Care and Health Apps, the British Audiology Association, and the National Institute for Health and Care excellence. It also won Children’s app of the year at the UK app awards in 2019.
Your child can wear the headset at school, at home or for speech and language therapy. The microphone should be worn by the person whose voice your child needs to hear clearly, such as a teacher, parent, therapist or other family member/friend. An introduction sheet for teachers can be found at the bottom of this instruction sheet.

The headset can be worn during sports such as PE, running, cycling etc, but cannot be worn while swimming or bathing.

**Intended use**
This product set is intended to be used to aid hearing in children diagnosed with a mild – moderate conductive hearing loss. This conductive hearing loss could be caused by Glue Ear (a build-up of fluid/mucus behind the ear drum) or other causes. The product set is not indicated for children with purely sensorineural hearing loss. Your research team or clinical team will prescribe use of this product only if your child has the correct type of hearing loss. The products can be used for up to 4 -6 hours per day before needing to be recharged. It is recommended that they are used at school, in situations where there is background noise or, if your child is struggling to hear instructions. Your child should be encouraged to make adults aware if the sound is too loud or if they can’t hear so that volume levels can be adjusted. They can always take the headset off, if they would like a break from wearing it. Please see the section of volume levels for adjusting if needed.
Instructions for Use

Before use, please check that the product has all the correct parts included:

- The headset
- Charging cable for headset
- The microphone
- Charging cable for microphone
- Instructions for use

Charging
Both elements of the system, the headset and the microphone, need to be fully charged prior to use.

The leads can be connected to a USB port on a computer or laptop, or to a USB plug for charging, as shown.

When the microphone is charging, the amber LED will light up. It will turn off when the microphone is fully charged.

The headset takes an hour and a half to completely charge. When charging the LED will be red. Once charged the LED will turn blue.

WARNING: Only use the provided leads to charge the devices.

WARNING: Do not use the devices whilst charging.

Wearing the headset and microphone
Videos are available to follow on the [www.heargluearer.wordpress.com](http://www.heargluearer.wordpress.com) website under the section ‘Research during Covid-19’. Your clinical team will also be able to tell or show you how to wear the headset during remote clinical consultation. During use, the headset is worn such that the vibrating speakers sit just in front of the ears, on the cheek bones. The headband sits behind the neck, as seen in Figure 4a.

To check if the headset is working, an adult can place the headset on their cheek bones as shown in Figure 4b.
**Figure 4: How to wear the products**

<table>
<thead>
<tr>
<th>Figure 4a– Headset worn correctly</th>
<th>Figure 4b– Headset worn wrong way round for testing</th>
<th>Figure 4c Microphone worn correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Headset worn correctly" /></td>
<td><img src="image2" alt="Headset worn wrong way" /></td>
<td><img src="image3" alt="Microphone worn correctly" /></td>
</tr>
</tbody>
</table>

The microphone needs to be worn securely attached to clothing, with no lanyards or scarves worn around the neck, as shown in Figure 4c. Adjust the direction of the microphone to your mouth by rotating the Bluetooth Microphone.

**Using your headset with the microphone**

1. Turn on the headset (it will say “power on”). To pair the headset with any device HOLD your finger down on the triangular multifunction button (see picture below) for 5 seconds, until the LED flashes blue and red and the device says “Pairing”.

2. Ensure that the microphone is switched to Type A:
3. Turn on the microphone on and into Type A pairing by pressing the on/off button for 2 seconds until the LED flashes blue.

4. The headset will automatically connect to the microphone and say "Connected". The blue LED on the microphone will change to flash slowly. (This can take up to 30 seconds).

5. The headset can now be placed on your child’s head as shown in Figure 4a.

6. Remember to turn both the microphone and headset off after use:
   To turn off the microphone, press and hold the on/off button for 2 seconds, the amber LED will stay on for 1 second and then turn off. Release the on/off button.
   To turn off the headset, press and hold the on/off button. You will hear the headset say, “power off”.

**Using the Microphone:**
The microphone can be used in unidirectional and omnidirectional settings. Both have their advantages for different applications. It is important to make sure that you are speaking into the correct mic depending on the setting:

If you wish to use the external microphone attach this to the audio port and select the External Mic button on the microphone:
If you wish to mute the microphone, press and hold the G- button for 2 seconds. Press the G+ button to unmute. Whilst the microphone is muted, the power button LED will flash blue-amber-blue.

**Using your headset with smart phone or tablet**

You will need to pair the headset to your smart phone or tablet to use the Hear Glue Ear app. Pairing enables the two devices to talk to each other.

1. Ensure that the microphone is turned off. You will not need the microphone for this.
2. Turn on Bluetooth on your mobile device
3. Press and hold the on/off button on the headset for 5 seconds until the headset says “Pairing” and the LED blinks blue and red.
4. The headset should now be visible on your mobile device as “G18”. Select the headset on your mobile device and the two products should then pair.
5. The headset will say “Connected” once the pairing is complete.
6. Once paired, any sound from the mobile device will be sent to the headset.

**Warning**: Be aware that all sound from the mobile device will be transmitted to the headset. Remember to disconnect or turn off Bluetooth once the child has finished using the mobile device.

**Volume levels**

The volume level will have been set at a default mid volume setting. Always adjust the volume from the headset: never use the microphone to adjust the volume. If your child complains about the volume level, you are able to adjust this by using Button + on the headset to increase volume, and Button - to decrease volume. This must be done whilst sound is playing through the headset.

We advise to only change the volume by one or two increments each way. The base volume level set is at the middle of the volume range of the device. If you need to reset to this level, please follow the procedure below:

1. Pair headset to a mobile device and play music through the mobile device.
2. Using ‘Button -’ to turn the volume down as low as possible. You will hear a tone each time you press the button. At the bottom of the volume level you will hear another tone.
3. From the lowest level, use ‘Button +' to increase the volume 8 times. This is the middle of the volume range.

**Trouble shooting**

You can check if the device is functioning correctly by placing the headset on to your own cheek bones as shown in Figure 4b and tapping or blowing on the microphone. You should hear the sounds through the headphones.
## Lights and indications on the product

<table>
<thead>
<tr>
<th>Indication</th>
<th>Meaning</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Headset</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED Solid red colour</td>
<td>Charging</td>
<td>None</td>
</tr>
<tr>
<td>LED Solid blue colour</td>
<td>Charging complete</td>
<td>None</td>
</tr>
<tr>
<td>LED Flashes red and blue</td>
<td>Pairing mode</td>
<td>Pair to microphone or mobile device</td>
</tr>
<tr>
<td>LED Blue double flash every 3 seconds</td>
<td>Connected</td>
<td>Connected to phone tablet or microphone</td>
</tr>
<tr>
<td>LED rapidly flashes red</td>
<td>Low battery</td>
<td>Charge device</td>
</tr>
<tr>
<td><strong>Microphone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED amber colour</td>
<td>Charging</td>
<td>None</td>
</tr>
<tr>
<td>LED flashes blue every two seconds</td>
<td>Paired to headset</td>
<td>None</td>
</tr>
<tr>
<td>LED flashes blue every five seconds</td>
<td>Not connected</td>
<td>Turn both headset and microphone off and follow Instructions to pair to headset</td>
</tr>
<tr>
<td>LED flashes blue rapidly</td>
<td>Type A pairing mode</td>
<td>Ensure headset is in pairing mode</td>
</tr>
<tr>
<td>LED flashes blue and amber alternately</td>
<td>Type B pairing mode</td>
<td>Switch to type A pairing mode and follow instructions to pair to headset</td>
</tr>
<tr>
<td>LED flashes blue-amber-blue</td>
<td>Mute</td>
<td>Press the G+ button to unmute</td>
</tr>
</tbody>
</table>

## Problem | Solution
---|---

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<table>
<thead>
<tr>
<th>Issue</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child cannot hear properly when I walk away from them</td>
<td>The products work over a range of 10m, ensure the microphone and headset are always within this distance. If the microphone goes out of range it may disconnect and the blue light will flash blue at 5-second intervals. Turn both the microphone and headset off and follow the instructions to reconnect.</td>
</tr>
<tr>
<td>The volume is too loud</td>
<td>Turn the volume down by using Button - whilst talking into the microphone or while connected to a mobile device playing music.</td>
</tr>
<tr>
<td>The volume is too quiet</td>
<td>Turn the volume up by using Button + whilst talking into the microphone or while connected to a mobile device playing music.</td>
</tr>
<tr>
<td>When I try to change volume the headset just states the battery level</td>
<td>There needs to be sound playing through the headset to change the volume. Either try changing volume whilst talking into the microphone or connect the headset to a mobile device playing music to adjust the volume.</td>
</tr>
<tr>
<td>The microphone will not pair with the headset</td>
<td>Ensure both items are fully charged. Check that the microphone is set to Type A pairing mode. Turn both the headset and microphone off and follow instructions to pair to headset.</td>
</tr>
</tbody>
</table>

**Warning:** Neither product contains user serviceable parts. Do not attempt to dismantle or open the products.

**Warning:** The product cannot be used while it is charging.

**Warning:** This product cannot be used under water. It is water resistant but not waterproof. Do not wear for swimming, bathing or showering. If the product gets wet, turn it off and allow it to dry naturally before using.

**Disposal**

The products should not be disposed of in normal household waste. They must be returned to the clinical department who issued them.

**Information for Teachers**

Thank you for agreeing to use the Hear Glue Ear Assistive Hearing Products in the classroom – here is our guide to activating the device to allow the child to hear well. If you have used an ‘FM' device before, then this works in a very similar way.

**The reason the child needs to use the device:**

The device is for children who cannot hear properly because the middle part of their ear does not work correctly. This might be a temporary or permanent problem. For the child it
feels a bit like their ears are blocked, or as if they are walking around with their fingers in their ears all day. This headset directs sound along the child’s cheekbones, bypassing the middle part of the ear, and accessing the normal part of their inner hearing instead. Therefore, with the headset the child hears more easily. The child and their family has agreed to be part of a research study which is assessing children using this product when other services are reduced, closed or not easily accessed as a result of the coronavirus pandemic.

**How to operate**

1. Remove all staff badges, scarves or necklaces that may touch the microphone or interfere with it. Clip it onto your clothing.

2. Turn the headset on:
   a. EITHER …Ask the child to turn on their headset – the parent may have already done this. OR…
   b. If you need to help by turning the headset on for the child, the easiest thing to do, is to place the headset on your own cheekbones (as in the picture). Press and hold the on/off button (The triangular button on the front of the headset) for 5 seconds, until the LED flashes blue and red and the device says “Pairing”.

3. Ensure that the microphone is switched to Type A:

4. Turn on the microphone on and into Type A pairing by pressing the on/off button for 2 seconds until the LED flashes blue

5. The headset will automatically connect to the microphone and say “Connected”. The blue LED on the microphone will change to flash slowly. (Do not be concerned if this takes up to 30 seconds).

6. The headset can now be placed on your child’s head as shown in Figure 4a.

7. Remember to turn both the microphone and headset off after use:
   - To turn off the microphone, press and hold the on/off button for 2 seconds, the amber LED will stay on for 1 second and then turn off. Release the on/off button.
   - To turn off the headset, press and hold the on/off button.
To reduce background noise, use the microphone in unidirectional mode by pressing the button below:

![Uni Mic Switch](image)

**MUTING THE MICROPHONE:**

If you wish to mute the microphone (e.g. when speaking to other children) press and hold the G- button for 2 seconds. Press the G+ button to unmute. Whilst the microphone is muted, the power button LED will flash blue-amber-blue
Appendix 2: Comments parents wrote about their child using the bone conduction kit.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Positive comments</th>
<th>Neutral comments</th>
<th>Negative comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact on hearing</strong></td>
<td>“He says to everyone, &quot;I can actually hear you now&quot;. &quot;He put his headset on yesterday, and his face lit up like I’ve NEVER seen! He said over and over again, &quot;I can hear everybody, I can hear everybody! Wow, wow, wow, I’m freaking out!&quot;. It is no exaggeration to say this has made an astronomical improvement to his quality of life” “I wish I had filmed it when he first tried it on, he said &quot;I can actually hear”” “The look on his face when he could hear was priceless” “He said &quot;oh my god! I can hear everything.” It was obvious by his face. He was so surprised”. <strong>Child:</strong> “It definitely helps with being able to hear”. “I can hear my best friend better now”</td>
<td>“He did like them. They are comfortable. He said he could hear better, that’s the only thing I can go off.” “We only have them connected to the iPad so I can’t tell if she can hear better”</td>
<td></td>
</tr>
</tbody>
</table>

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<p>| Impact on anxiety/ worry | “Definitely happier and calmer when wearing headphones”. “She is less emotional, a happier child when she has it on and less tired from lip reading”. “School has a fire drill, he didn’t scream and cry or ask for his ear defenders” (for a child who had previously become dependent on wearing noise cancelling ear defenders for anxiety around loud sounds at school) | “He’s more chilled, he didn’t get shouted at”. | “She feels anxious when headphones aren’t working or charged”. |</p>
<table>
<thead>
<tr>
<th>Impact on speech and language</th>
</tr>
</thead>
</table>
| “She speaks more normally [when wearing the head phones]. Phonics at school - she is pronouncing ’ch ’and ’m ’clearer”.
| “He used to get the next door neighbour’s name wrong but when he said it right the other day, we was all shocked, even she was shocked”.
| “She wears the headphones to sing along to Mamma Mia and she now sings the words more clearly”.
| “It’s made a big difference to how she hears and her speech. She had gone back [during lockdown] to signing for ‘hungry ’ and ‘drink ’from Mr Tumble. The signing stopped with the headphones”.
| “He was so upset when head set wasn’t working. Little things started creeping in. His speech regressed really quickly. He wasn’t starting his words properly”.
| “Better pronunciation when wearing it”.
| “It’s worked really well for her, aiding her speech development. It’s a positive outcome for her”.
| “He speaks at a better volume level himself when he is wearing headphones”.
| “His speech is coming on so well in just a week”.
| “There is a quite a change in how he is saying words. He is able to correct himself more easily when wearing the headphones”.
| “Other people have said, ”wow his speech is more clearer”” |

| “Her speech is generally improving, although I’m hesitant to say the extent etc. I’ve been surprised at times the length of word she’s used or the complexity of the sentence or that she’s heard and repeated something that I’ve said. However, there are still lots of times when her speech is slurred, or I cannot immediately get what she is trying to say and it’s not clear.” |

| “His speech is still bad whether he wears them or not”.|

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| Impact on school/learning | “His learning is much quicker. It’s given him a kick start”.
“Her vocabulary is also markedly improved, as is her reading”.
“According to his teacher he is now sitting for circle time for the whole amount of time, before he would get up half way through.”
“Thank you so much for giving us the opportunity to use the headphones, they certainly helped her and meant that she didn’t fall behind with her phonics or speech.” |
| Teachers | “He engages with the key worker [at nursery] and other kids better with the headphones”.
“She continues to consistently wear the headphones at nursery for three days. The staff’s view is that they make a massive difference there as I previously mentioned: more attentive and responsive to what staff say”.  
Child  
“I know how to mute it. I was the person who showed my teacher how to do it, [before] when she was talking to another teacher she would hold the mic away as far as she could stretch her arm.” |
|  | Child “I keep them in my tray. Miss T charges them on her desk.”
“Could you give information to the teachers to do something for deaf awareness week”.
“Nursery slowly got used to it.” |
|  | “Teachers are worried about Covid and won’t swap the mic between them so she can’t hear when she has a replacement teacher once a week and can’t hear in PE.”
“The teachers are so busy and stressed. I don’t want to stress them more”.  
“The teacher is going to see how he goes and then decide whether we should use it” |
|  | “She doesn’t want to wear them much at school as she is conscious of what the other children in her class think of her.” |
| Impact on home life          | “The TV volume stays down now, we just place the microphone by the TV”  
|                            | “The interaction between the boys [siblings] has been better”  
|                            | “She [10y] is relying on it enormously..has paired it to everything in the house. It is now the way she watches TV. She has taken it out with her friends”.  
|                            | “She is getting on really well with the headphones - we've not tried them in school with the mic yet, however pairing them with the iPad at home is simply brilliant. She loves the freedom they give her and obviously, the hearing ability.”  
|                            | “There have been fewer arguments because he could communicate more effectively”.  
|                            | “Everyone at home raised their voices less”  
| Impact on fatigue           | His brother was fed up because he'd had the same trouble, he was like “why didn’t I get anything like that?”  
|                            | “If I am wearing the microphone and walk outside her bedroom the connection is often bad.”  
|                            | “I think a hearing aid would be easier so he could hear all the time”  
|                            | “She doesn’t want to wear it at home having worn it all day at nursery”.  
| Self confidence             | “She is not as tired when she comes home from school”  
|                            | “He is less tired after a day of wearing the headphones”.  
|                            | “I wasn’t sure how she would cope with the other children [at school] but she wants to hear”.  
|                            |
| **Impact on the parent** | “If we hadn’t been part of the study..I do worry about hearing..it’s made me more chilled”.
“My biggest worry was that she couldn’t hear and her pronunciation sounds like a deaf child. Having the headphones, I’m not panicking that she is going back to where she was”.
“I could talk to her at a normal level, rather than shouting.”
“It makes me quite emotional how crazy she became when she tried them the first day...makes me realise that she could hear much better I think”.
“They[headphones] also put my mind at rest as knowing she could hear meant I was less worried about when she would have her operation as I knew she was not falling behind in her speech development” |
| **Attention and concentration** | “He is very focused when wears the headphones. Beforehand it would have been ‘what’s that? Huh?’
“He has always struggled with concentrating and listening.
His teacher says he looks up more [when wearing the headphones].”
“He’ll listen to audiobooks to the end now rather than listening to only one or two pages” |
| | “Shopping trips were easier [when wearing the headphones], she could chat to me and she wasn’t frightened she would lose me”.
“He heard my voice, he smiled so much” |
| The headset | “When I wore them at school my friends pretended to play guitar. My friends said ‘when you were wearing the headset you look like a rock girl’”
“He thinks it’s pretty cool, he thinks it’s like a robot like thing”.
“He is very protective over his headphones. The teacher was worrying about them getting damaged and I said ‘no fear, he won't let anyone touch them’”
“The headphones give a visual cue to others that she has a hearing loss” | “Can children get their own from a shop? My friend wants one”.
Child “I might need to wear them until I'm an adult. I might need a bigger size”.
“A boy commented [teased] and now she really doesn’t want to wear them at school.”
Child “Tell other children to be careful with it, don't wear it at break times or lunch time. I am not wearing it in the playground” | 

| Social communication | “Staff also comment that it makes a massive difference with friends - she can hear and interact with them better and they can understand what she says” | “When you are learning language, life, and social skills, whether it is small or not, you are missing something if you can't hear” |

| The Hear Glue Ear app | “The app appeals to her”
“It was very helpful to have the hearing test in the app” | “The app needs to have an older children section”.
“she has got through all of the stories songs and games on the app [in lockdown], the app needs to have more on it.” |
<table>
<thead>
<tr>
<th>General comments</th>
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<tbody>
<tr>
<td>“I can’t tell you how much it has helped”.</td>
<td>“We would rather avoid grommets”.</td>
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<tr>
<td>“It has made a massive difference to her.”</td>
<td>“We were quite shocked at how low her hearing was when tested last year and the need for her to have an operation, personally I’d like to avoid that if possible, but just don’t want her to feel isolated and fall behind.”</td>
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<tr>
<td>“It’s nice to get something to help really”.</td>
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<td>“This has really helped”.</td>
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<tr>
<td>“All his violin lessons for 10 months have been online. He used the headphones paired to iPad for zoom lessons. He just passed his exam”.</td>
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<tr>
<td>“We were so desperate and we had run out of options. This is just brilliant. We are over the moon to be part of the study”.</td>
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<td>“I have been wanting to support [my child] with something like this”.</td>
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<tr>
<td>“We are grateful for them...the first two years at school are so important.”</td>
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<td>“He was excited to have something that was just his”.</td>
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<td>“I think this has been a fantastic research project and I hope that many more children get to benefit from having access to these whilst they wait for operations.”</td>
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<td></td>
<td>“If she had only had this a few years ago. We needed it then.”</td>
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<td></td>
<td>“I wish we had been given this while he was at primary school. We didn’t think it was a good idea for him to wear them as he starts secondary school”</td>
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Wireless kit might be cheap alternative to usual treatment of ‘glue ear’ in kids

Comprises headphones, microphone, plus app; acceptable to children and parents

A wireless kit, comprising headphones, a microphone, and an app might be a cheap alternative to the usual treatment of the common temporary hearing loss in kids, popularly known as ‘glue ear,’ finds a small study, published in the online journal BMJ Innovations.

It may avoid the need for surgery in many cases, and could cut down on clinic visits, by enabling parents to monitor their child’s hearing remotely at home, say the researchers.

Glue ear (otitis media with effusion), occurs when the middle part of the ear fills up with sticky fluid, usually after a cough, cold, or ear infection, causing temporary hearing loss in one or both ears.

One in 10 children starting school in the UK or Europe will have some hearing loss caused by glue ear.

Deafness in young children can interfere with speech development, language, communication, auditory processing, self-esteem, socialisation, listening and learning, say the researchers.

Current solutions are far from ideal. A grommet, or T-tube, is a small tube designed to drain fluid away and keep the eardrum open, but it requires insertion under general anaesthetic.

Around a third of children fitted with them will develop an infection as a result; and in a small percentage of cases, grommet insertion risks perforating the eardrum or permanent scarring.

Hearing aids require several audiology appointments to adjust sound levels correctly, because the condition fluctuates.

And hearing aids that enable sound to vibrate through the skull bone directly to the cochlea (inner ear bone), so bypassing the eardrum and middle ear, are very effective. But they are expensive.

Bone conduction headphones, however, which are marketed to cyclists, allow sound from mobile phones to be directed straight to the cochlea while not blocking out vital sound from traffic, and are much cheaper.

The researchers wanted to find out if the commercially available Bone Conduction Kit, comprising a wireless headset plus microphone, paired with the freely available Hear Glue Ear app, would enable children and their parents to manage glue ear effectively at home.

The parents of 26 children diagnosed with glue ear and/or scheduled for grommet insertion in the local area during the first wave of the 2020 COVID-19 pandemic in the UK, were sent the kits and details of the app.

They filled in an Otitis Media Quality of life questionnaire within 3 weeks of kit receipt to assess the impact of ear problems on their children with and without the kit. Progress was monitored via remote virtual or phone consultations over the subsequent 3 months.

The children, who were all aged between 3 and 11, made up 82% of those on the local surgical list for grommet insertion. Their average level of hearing loss had been measured as mild.
Twenty families set up the kit successfully straight away; four others waited for a call. After the initial set-up, four families required additional help to use the kit later on.

In the 3 months before the kit was supplied, 19 sets of parents said their child’s hearing had been poor or very poor. None of the parents reported this while using the kit, with 24 reporting it as ‘normal’ or only ‘slightly below normal’.

Twenty three parents reported that their child ‘often’ or ‘always’ had difficulty hearing in a group before the kit’s arrival, compared with 22 out of 26 saying their child rarely or never had problems hearing in a group when using the kit.

Two thirds (17) used the app at home, 8% (2) on car journeys, and 26% (7) didn’t use it at all. Fifteen (58%) of the children took the kit to school or nursery.

One family commented that the school took their child’s hearing more seriously as a result; one parent said the headset was a visual cue to others that their child needed support. But three mentioned schools needed more support, or more resources, to use the kit at school.

By the end of 2020, none of the children had had a grommet inserted. Three families said they would continue to use the kit rather than have a grommet inserted.

All families chose to keep the kit at the end of the study, even if the child’s hearing had improved. Most found remote management acceptable and thought their child had benefited.

The researchers acknowledge that the study was short term, didn’t include a comparator group, and only involved a small number of children.

But remote management of glue ear in this way has many advantages, they point out, including improving children’s hearing at an important stage of their development; reducing travel to clinics with small children; and enabling children to hear online learning more clearly.

“Innovative use of bone conduction headphones, a microphone and the Hear Glue Ear app, sent through the post to patients, is a novel, new and effective approach to the management of glue ear and its resulting hearing loss, especially when families have reduced access to audiology or Ear Nose and Throat (ENT) services, such as during the COVID-19 pandemic,” write the researchers.

Further larger scale studies are needed to look at the cost effectiveness and clinical effectiveness at scale, they say. But they add that this option might avoid the need for grommets in many cases of glue ear, while enabling mild, fluctuating cases to be offered early hearing support.