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The effect of N95 masks on speech recognition in patients with hearing loss

N95 maske kullanımının işitme kaybı olan hastalarda konuşmayı anlama üzerine etkisi

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ABSTRACT

Objectives: The aim of this study was to investigate the effects of N95 masks on speech recognition threshold (SRT) and speech discrimination scores (SDS) of individuals with normal hearing and those with hearing impairment.

Patients and Methods: This prospective study included 121 patients between June 2021 and November 2021. Individuals with normal hearing and patients with very mild, mild, moderate, and moderate to severe hearing loss were included. The SRT and SDS were measured while the audiologist was wearing or not wearing an N95 mask.

Results: The SRT and SDS values decreased significantly in all study groups, including the normal hearing group, when the test was performed while the audiologist was wearing an N95 mask ($p<0.001$ for all).

Conclusion: Speech understanding was negatively affected in individuals with normal hearing and those with hearing impairments when the audiologist wore an N95 mask. However, the effect of the N95 mask on speech discrimination was more pronounced in hearing-impaired individuals than those with normal hearing.

Keywords: COVID-19, N95 mask, speech discrimination score, speech recognition threshold.

ÖZ

Amaç: Bu çalışmada, N95 maske kullanımının normal işiten ve işitme bozukluğu olan bireylerin konuşmayı algılama eşiği (SRT) ve ayırt etme skorları (SDS) üzerinde etkileri değerlendirildi.

Hastalar ve Yöntemler: Bu prospektif çalışmaya Haziran 2021 - Kasım 2021 arasında 121 hasta dahil edildi. Normal işiten bireyler ve çok hafif, hafif, orta ve orta ağır işitme kaybı olan hastalar çalışmaya dahil edildi. Odyometrist N95 maskesi takarken veya takmazken SRT ve SDS ölçümleri yapıldı.

Bulgular: Odyometrist N95 maske takarken test yapıldığında, normal işiten grup dahil, tüm çalışma gruplarında SRT ve SDS değerleri önemli ölçüde azaldı (tümü için $p<0.001$).

Sonuç: Odyometrist N95 maske takarken normal işiten bireylerde ve işitme kayıplı bireylerde konuşmanın anlaşılması olumsuz etkilendi. Ancak N95 maskenin konuşmayı ayırt etme üzerindeki etkisi işitme kayıplı bireylerde normal işiten bireylere kıyasla daha belirgindi.

Anahtar sözcükler: COVID-19, N95 maske, konuşmayı ayırt etme skoru, konuşma tanıma eşiği.

The coronavirus disease 2019 (COVID-19) pandemic led to significant changes in our daily lives. To prevent or slow down the dissemination of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), individuals and governments undertook some measures, including use of facemasks sand social distancing.[1,2] In hospitals, the use of personal protective equipment (PPE) was compulsory for all healthcare workers during the pandemic.

In the COVID-19 era, healthcare workers faced communication issues with their patients, particularly with those with hearing impairment. Surgical masks and

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face shields have been shown to cause speech perception problems in individuals with hearing impairment.[3] Facemasks that provide aerosol filtration such as N95 masks have been preferred by otorhinolaryngologists since significant aerosol production is possible during otorhinolaryngologic examination and interventions. Bandaru et al.[4] showed that N95 masks worn by audiologists significantly increased the speech recognition threshold and decreased the speech discrimination score in the individuals with normal hearing. However, no studies up to date investigated the effect of N95 masks on understanding of speech in individuals with hearing impairment. Hence, this study aimed to investigate the effects of N95 masks worn by healthcare professionals on speech recognition threshold (SRT) and speech discrimination score (SDS) of individuals with normal hearing and those with hearing impairment.

PATIENTS AND METHODS

This prospective descriptive study was conducted with a total of 242 ears of 121 patients (70 males, 51 females; mean age: 51.8±19.5 years; range, 18 to 95 years) who applied to the Otorhinolaryngology Outpatient Clinic of the Kartal Dr. Lütfi Kırdar City Hospital between June 2021 and November 2021 and who underwent audiological tests for various reasons. The inclusion criteria were age >18 years, symmetrical hearing levels, and fluency in Turkish. The study protocol was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (date: 26/05/2021, no: 2021/514/202/8). Written informed consent was obtained from all participants. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Pure tone audiometry was performed at 0.5, 1, 2, and 4 kHz. The hearing levels measured in the right and left ears were classified according to the pure tone averages (PTAs) of the patients. A PTA between 0 and 20 dB was categorized as normal hearing, a PTA between 21 and 35 dB was categorized as very mild hearing loss (HL), a PTA between 36 and 45 dB was categorized as mild HL, a PTA between 46 and 55 dB was categorized as moderate HL, and a PTA between 56 and 70 dB was categorized as moderate to severe HL. Patients with severe (71-90 dB) and profound (>90 dB) HL were excluded from the study.

After the PTAs of the patients were determined, the SRT and SDS of the participants were measured in an audiometry cabinet while the audiologist was not wearing an N95 mask, and the measurements were repeated with the audiologist wearing an N95 mask. Live voice was used while determining the SRT and SDS. To determine the SRT, six three-syllable words were spoken 10 to 15 dB above the PTA of the patient. If the patient could repeat all the words correctly, the volume was reduced by 5 dB, and another list of three-syllable words was spoken. The volume was reduced by 5 dB every time the individual repeated all the words correctly. If the individual answered 50% of the words incorrectly, the volume (dB) at the previous step was recorded as the patient's SRT score. For the SDS test, the most comfortable level was determined by adding 25 to 40 dB above the patient's SRT level. Twenty-five single-syllable words were spoken to the patient. The correct and incorrect answers were counted. Correct answers were multiplied by four, and the SDS was determined. The values with the speaker wearing the N95 mask and without wearing the mask were compared in every study group and among the study groups.

Statistical analysis

Statistical analyses were performed using NCSS 10 software (NCSS LLC, Kaysville, UT, USA). The Shapiro-Wilk test, histograms, Q-Q plots, and boxplots were used to analyze the normality of the data distribution. Data were presented as median, minimum-maximum, frequency, and percentage. The Wilcoxon signed-rank test was used with and without the N95 mask comparisons. Comparisons among the groups were performed using the Kruskal-Wallis multiple comparison Z-value test (Dunn's test). The chi-square test was used to analyze the sex variable among the groups. A p-value <0.05 was considered statistically significant.

RESULTS

The study groups were similar for sex distributions, except for the moderate to severe HL group (Table 1). When the groups were classified according to the mean age, it was found that the normal hearing group was significantly younger than the other groups. There were 28 individuals in the normal hearing group, 32 patients in the very mild HL group, 20 patients in the mild HL group, 21 patients in the moderate HL group, and 20 patients in the moderate to severe HL group. Pure tone averages were determined as 10.5 dB in the normal hearing group, 27.3 dB in the very mild HL group, 40.1 dB in the mild HL group, 52.2 dB in the moderate HL group, and 63.3 dB in the moderate to severe HL groups.

The SRT and SDS decreased significantly in all study groups when the test was performed while the audiologist was wearing an N95 mask (p<0.001 for all

Table 1
Sex distribution and mean ages of the study groups

	Male		Female		
	n	%	n	%	*p*
Normal hearing	10	35.7	18	64.3	36.3
Very mild HL	19	59.4	13	40.6	51
Mild HL	17	85	3	15	60
Moderate HL	13	61.9	8	38.1	59.3
Moderate/severe HL	11	55	9	45	58.6

HL: Hearing loss.

groups, Table 2). The changes in SRT and SDS due to the N95 mask were determined by subtracting the values obtained without a mask from those obtained with a mask. The comparison of the study groups for SRT change and SDS change showed significant differences among the study groups (p=0.001 for SRT and p=0.009 for SDS; Figures 1, 2).

The SRT in the normal hearing group was less affected by speaker-worn N95 mask compared to the very mild (Z=2.57, p<0.05), moderate (Z=3.31, p<0.01), and moderate to severe (Z=2.22, p<0.05) HL groups. The SRT was similarly affected by the N95 mask in the normal hearing and mild HL groups (Z=0.14, p>0.05). It was evident that patients in the mild HL group were less affected than those in the moderate (Z=3.18, p<0.01) and moderate to severe (Z=2.18, p<0.05) HL groups. In contrast, the individuals in the moderate to severe HL group were affected similarly to those in the moderate HL group (Z=0.97, p>0.05).

Comparison of the study groups for SDS change with and without the N95 mask showed that the normal hearing group was less affected than the very mild (Z=2.97, p<0.01), mild (Z=3.03, p<0.01), and moderate to severe (Z=3.03, p<0.01) HL groups.

Table 2
The SRT and SDS of the study groups while the speaker was wearing or not wearing an N95 mask

	SRT			SDS		
	Median	Min-Max	*p*	Median	Min-Max	*p*
Normal hearing (n=56)						
Without N95	5	0-25	<0.001	96	60-100	<0.001
With N95	10	0-25		88	48-96	
Very mild HL (n=64)						
Without N95	15	5-30	<0.001	82	36-96	<0.001
With N95	22.5	5-45		72	20-88	
Mild HL (n=40)						
Without N95	35	20-45	<0.001	68	16-92	<0.001
With N95	37.5	20-55		56	4-84	
Moderate HL (n=42)						
Without N95	45	25-70	<0.001	64	36-88	<0.001
With N95	55	30-80		56	16-80	
Moderate/severe HL (n=40)						
Without N95	60	50-75	<0.001	58	12-80	<0.001
With N95	65	50-85		46	3-76	

SRT: Speech recognition threshold; SDS: Speech discrimination score; HL: Hearing loss.

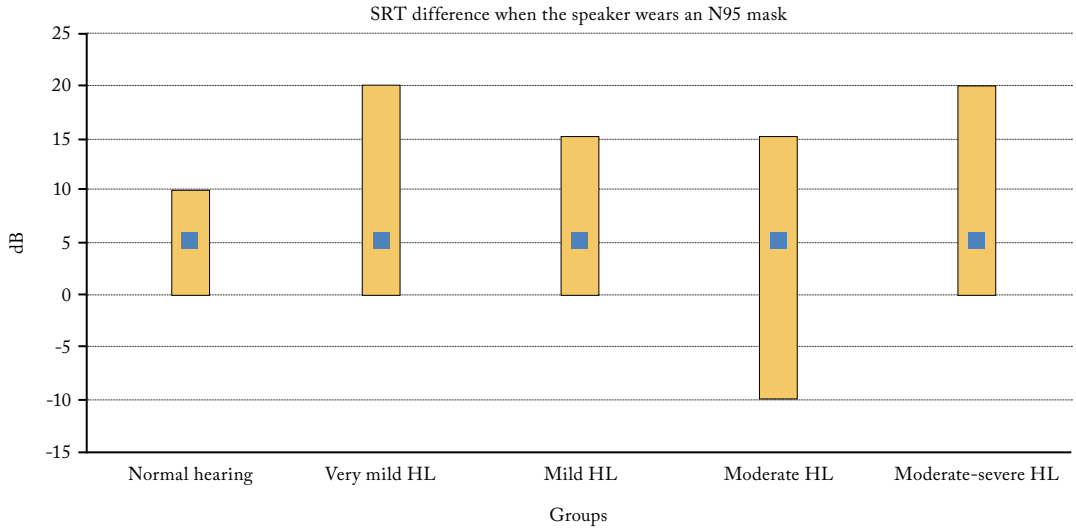

Figure 1. Changes in the SRT of the study groups when the speaker wore or did not wear an N95 mask.

SRT: Speech recognition threshold; HL: Hearing loss.

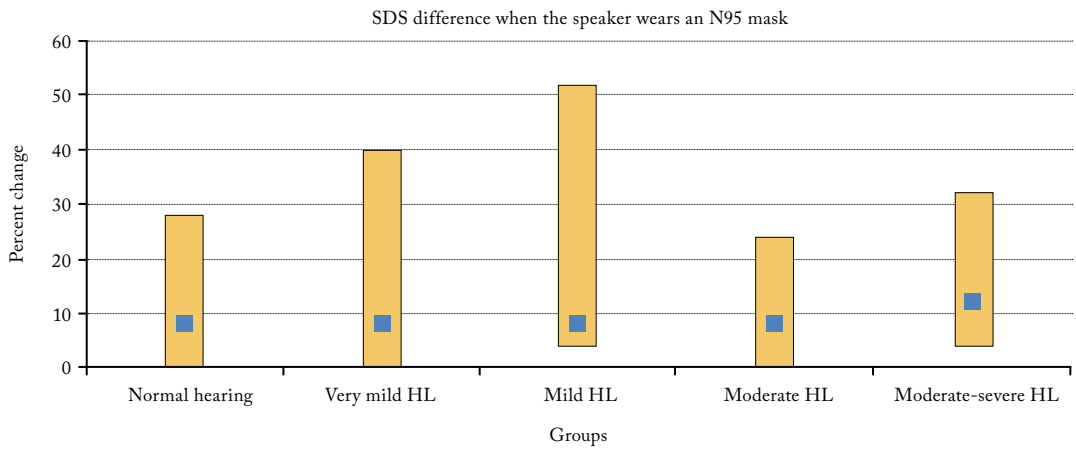

Figure 2. Changes in the SDS of the study groups when the speaker wore or did not wear an N95 mask.

SDS: Speech discrimination score; HL: Hearing loss.

DISCUSSION

The results indicated that SRT and SDS were significantly impaired in normal-hearing and hearing-impaired individuals when the speaker wore an N95 mask, and understanding of speech was more affected in hearing-impaired individuals than in normal-hearing individuals.

The community-wide use of facemasks has brought mask-related issues into discussion. It is recognized that facemasks cause communication problems. It was reported that facemasks act as low-pass acoustic filters for speech, attenuating frequencies between 2 and 7 kHz, 3 to 4 dB for facemasks and 12 dB for N95 masks, causing degradation of speech quality.[5] Facemasks also hide mouth and facial mimics, and hence, hide visual clues of speech,[3,6] which may affect hearing-impaired individuals more than normal-hearing individuals.

The effects of surgical masks on the understanding of speech have been studied by various authors.[3,7-10] Yi et al.[7] reported that listeners with normal hearing performed less well when the speaker wore a disposable facemask or a transparent mask compared to wearing no mask, and the presence of background noise worsened the listener's understanding.

Ensuring adequate and effective communication in healthcare institutions among healthcare professionals and between healthcare professionals and the patients is extremely important for proper execution of healthcare services. In the COVID-19 era, physicians and other healthcare workers wore masks in hospitals, and otorhinolaryngologists preferred tight-fitting N95 masks that prevent aerosol transmission since aerosol formation is possible during otorhinolaryngologic examination and interventions. The effects of N95 masks on communication problems were also studied.[4,8,9,11] Hampton et al.[11] performed a small study on five healthcare workers with normal hearing, and found that the FFP3 mask and face shields significantly worsened SDS in the case of a background noise level simulating the operating room background (70 dB) but not in the office (45 dB), emergency department (55 dB), or intensive care unit (65 dB) background noise simulations. The authors did not report whether SDS deteriorated in quiet when the speaker wore a PPE mask.[11] Bandaru et al.[4] studied 20 normal-hearing healthcare workers and measured their SRT and SDS while the audiologist was wearing and not wearing an N95 mask and face shield. They did not use any background noise and reported that the SRT increased (12.4 dB) and SDS decreased (7%) when the speaker used a PPE mask.[4] Toscano and Toscano[8] did not measure the hearing levels of their subjects and excluded the ones who self-reported HL and reported that facemasks, including N95 masks, had little to no effect on speech discrimination compared to a no masks in the case of a low background noise level. Rahne et al.[9] found that the mean reduction in speech perception threshold in noise was 2.7 dB in individuals with normal hearing when the speaker wore an N95 mask. In our study, we found that the median SRT increased by 5 dB and the median SDS decreased by 12% in individuals with normal hearing when the speaker wore an N95 mask (Table 2).

It is known that individuals with HL need more visual cues than normal individuals to understand speech. Therefore, individuals with HL are expected to have more difficulties in understanding speech compared to those with normal hearing when the talker wears a facemask. Homans and Vroegop[3] investigated the effect of surgical masks and face shields on speech intelligibility in 40 adults with moderate to severe HL using hearing aids or cochlear implants. The participants' hearing aids/cochlear implants were on during the test, and their speech perception was measured as 65 dB SPL in a quiet environment. The authors found that surgical masks had a more negative effect on speech tracking than face shields since the face shields did not hide the lips of the talker. The authors concluded that the worse the speech perception in quiet conditions at 65 dB SPL, the larger the impact of the surgical mask. They did not find any differences between hearing aid and cochlear implant users.

To date, the effect of N95 masks on speech intelligibility in individuals with hearing impairment has not been investigated. In our study, we found that SRT decreased by 7.5 dB in patients with very mild HL, 7.5 dB in mild HL, 2.5 dB in mild HL, 10 dB in moderate HL, and 5 dB in moderate to severe HL ($p<0.001$ for all). When SDS was considered, the SDS decreased by 10% in very mild HL, 12% in mild HL, 8% in moderate HL, and 12% in moderate to severe HL (Table 2). Our results showed that the understanding of speech was affected more in individuals with very mild, mild, and moderate to severe HL than in those with normal hearing.

Ambient noise negatively effects speech understanding. Mendel et al.[10] reported that speech understanding was not affected in either normal-hearing or hearing-impaired groups when the speaker wore a surgical mask in the absence of ambient noise. However, they found that dental office background sound reduced speech understanding in both groups. The difference between the mean scores in quiet and noisy environments for the hearing-impaired group was larger than that for the normal-hearing group, and they concluded that listeners with HL would have more difficulty with noise than those with normal hearing.[10] In our study, we did not test our subjects in the presence of ambient noise, which is a limitation of the study.

Bandaru et al.[4] argued that variables such as age, occupation, and sex may affect speech recognition and discrimination. However, in their study, they did not find any effect of these parameters. In the present study, there were differences among the study groups in terms of age and sex. In the present study, the normal-hearing group was significantly younger than the groups with HL, and there was a difference among the groups in terms of sex. Our study groups were not evaluated in terms of occupational status or sociocultural level. Larger patient groups are needed to determine the effects of these variables on SRT and SDS, and to obtain more comprehensive data.

Further studies are needed to evaluate speech discrimination in patients with different hearing levels in noisy environments when the audiologist wears an N95 mask. Also other mask types and face shields on srt and SDS values in patients with hearing loss were not evaluated.

In conclusion, results showed that the understanding of speech was negatively affected in both normal-hearing individuals and individuals with HL when the speaker wore an N95 mask. In addition, the effect of the N95 mask on speech discrimination was more pronounced in hearing-impaired individuals than those with normal hearing.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea, design, data collection, critical review: Z.E.Ç.; Writing, literature review, control/supervision, analysis and interpretation: H.B.

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