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"Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Survey of Staff Physicians, Residents and Medical Students."

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Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Survey of Staff Physicians, Residents and Medical Students

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Abstract

Introduction: The value of chest auscultation would be enhanced by the use of a standardised terminology. However, recommendations were made in English, and therefore, must be transferred to languages other than English (LOTE) without distortion.

Objective: To examine the influence of language skills on the transfer to Hebrew – taken as a model of LOTE - of the recommended terminology in English.

Design/Setting: Cross-sectional study; university-based hospital.

Participants: 143 caregivers including 31 staff physicians, 65 residents, and 47 medical students

Methods: Observers provided spontaneous, uninstructed descriptions in Hebrew, and English of audio-recordings of 5 sounds identified by computer analysis as: Normal breath sound (NBS); wheezes; crackles; stridor and pleural friction rub (PFR).

Outcomes: a) Rates of correct classification; b) Correspondence between correct Hebrew and recommended terms; c) Language and auscultation skills assessed by crossing the responses in the two languages with one another, and with the true classification.

Results: Range (%) of correct rating was as follows: NBS=11.3%-20%; Wheezes=79.7%-87.2%; crackles=58.6%-67.4%; stridor=67.4%-96.3%; and PFR=3.6%-28.6%. Of 60 Hebrew terms 10 were correct, but only 5 matched the recommended terms. Many Hebrew terms were adaptions or transliterations of ancient English terms, some of which are deemed inadequate. Observers were classified as having good language skills in 586 (83.5%) of 687 sessions of evaluation; of these, however, 265 (45.2%) lacked auscultation skills.

Conclusion: Poor auscultation skills largely surpassed poor language skills as a factor hampering the transfer to LOTE (Hebrew) of the recommended terminology. Improved education in auscultation is the most important measure to promote use of standardised lung sound terminology. Our results can help devise a strategy to encourage the use of standardised terminology in non-native English speaking countries.

Word count: 276

Key words: lung sound terminology; lung auscultation; observer variability; language other than English; LOTE

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Strengths and Limitations of the Study

- To our knowledge, this is the first study to examine the transfer to LOTE of the recommended lung sound terminology in English.
- True sound classification was based on computer-based sound analysis.
- Participants were from the same hospital which tends to limit the study generalizability – but had different clinical and educational background.
- Use of more complex sounds (e.g. rhonchus, squawk) might have further hampered the observers' ability to classify the sounds.

Introduction

Lung auscultation has been a traditional part of the chest examination since the invention of the stethoscope [1]. Whilst no other method equals auscultation in providing quick, cost-effective, and easily obtained, relevant information about the respiratory system, its value is limited by the confused terminology [2]. Even though recommendations on terminology have been developed [3-5] significant variation in the terms used to describe the sounds persists among health professionals [6-11].

To examine this variation, we invited staff physicians, residents, and medical students working in a university-based hospital in Israel, to spontaneously classify a set of common lung sounds presented to them in audio-recordings. They were asked to classify the sounds successively in English and Hebrew, taken as a model of a language other than English (LOTE). Different aspects of the survey were highlighted in two companion papers. The first paper, published recently, found that poor auscultation skills were the main factor influencing the choice of English terminology [11]. The second study, reported herein, examined the influence of language skills on the transfer, to LOTE (Hebrew), of the terminology recommended currently by scientific societies [3-5]. This aspect has practical importance. First, between-language differences hamper communication in teaching and in meaningful exchanges of auscultation findings between clinicians and researchers from different countries [10]. Moreover, they can cause divergent interpretations of the same sound even by caregivers from the same country. This study aimed to compare the Hebrew terms used by our observers, with (a) those recommended currently [3-5] and, additionally, with (b) the English terms they used to classify the same sounds previously [11].

Materials and Methods

These were described in detail previously [**11**]. Briefly, we recruited 143 caregivers, including 31 staff physicians (SP), 65 residents (R) and 47 medical students (MS) working at Shaare Zedek Medical Center, affiliated with the Hebrew University of Jerusalem. Participants were informed about the study through word-of-mouth. The study was submitted to the hospital's Ethics Committee, but no informed consent was deemed necessary.

Assessments

Upon arrival, participants received standardised instructions to fill in a questionnaire on background information including demographics, medical status, years of practice, and medical specialty.

Sound rating

Next, they were invited to listen through loudspeakers to the audio-files of 5 common lung sounds namely: 1. Normal breath sound; 2. Wheezes; 3. Crackles; 4. Stridor and 5. Pleural Friction Rub. The files, which were taken from a set of files published previously [2], were stored in a computer placed in a silent room. The observers classified the sounds in the order they were played (i.e. 1-5) and wrote "free-form" answers successively in English and Hebrew, describing the sounds with their own words in the appropriate columns. No sonograms or waveform analysis were provided to substantiate the nature of the sounds. However, each observer was informed about the site of sound recording and of the fact that all recordings started from an inspiration. The ability to correctly identify the sounds was determined by comparing the observers' response in Hebrew with the true classification obtained by computer-based waveform analysis of each sound,

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taken as gold-standard [2]. The rating was considered correct if a recommended term or an accepted synonym was used to describe it (term use ascribed to preference). The use of any incorrect term was ascribed to lack of skills on chest auscultation.

Language and Auscultation Skills

The ability to correctly classify the sounds depends both on language and auscultation skills. To assess this relationship, we crossed the responses in the two languages with one another and with the true classification obtained by computer analysis. Four groups were identified, as follows.

1. Caregivers with both language and auscultation skills: Those using correct, corresponding terms in the two languages to correctly classify the sound (e.g. use of, say, the terms "wheeze" and "tziftzufim' to classify the wheezes of audio sound # 2)

2. Caregivers with language skills but no auscultation skills. Those using correct, corresponding terms in the two languages to incorrectly classify a sound (e.g. use of "bronchial sound" and "neshima bronchialit" to classify the normal breath sound of sample # 1)

3. Caregivers with single-language skills and auscultation skills. Those using a *correct* term in one language only, to *correctly* classify a sound (e.g. use of the correct term "wheeze" and of the incorrect term "crepitaziot" to classify the wheezes of sound sample # 2).

4. Caregivers with neither language nor auscultation skills. Those using incorrect terms in the two languages to incorrectly classify a sound (e.g. use of the term "rales" or, say, "crepitatziot" to classify the pleural friction rub of sample # 5).

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No patient involved

Data Analysis

Baseline characteristics are presented as mean (SD) and proportions. For each audio sample, the difference in the proportion of correct vs. incorrect rating was isher's ex. tested using the Fisher's exact test; a p < 0.05 was considered significant.

For peer review only

Results

Characteristics of participants

Participants' mean (SD) age was as follows: SP= 48.4 yrs. (10.4); R=32.5 yrs. (3.5), and MS=28.4 yrs. (4.5). Overall, 17 (54.8%) staff physicians declared more than 20-year experience with auscultation; in turn, 60 (92%) residents and 47 (100%) medical students declared < 5-year experience.

Auscultation Skills

For each sound, the rates of correct sound identification were as follows: Sample #1 (normal breath sound): n=20 (14.6%) (SP=20%; R=11.3%; MS=14.9% [p=0.527]); Sample #2 (wheeze): n=116 (82.3%) (SP=80%; R=79.7%; MS=87.2%. [p=0.551]); Sample #3 (crackle): n=85 (65.4%) (SP=58.6%; R=67,2%; MS=67.4%; [p=.685]); Sample #4 (stridor): n=110 (84%) (SP=96.3%; R=90.2%; MS=67.4%; [p=.001]); Sample #5 (pleural friction rub); n=11 (9.1%) (SP=28.6%; R=3.6%; MS=2.7%; [p=.000]). Altogether, the observers used 60 Hebrew terms to classify the sounds. Of these, 10 (16.7%) were correct, being therefore ascribed to preferences regarding terminology, while 50 (83.3%) were incorrect, being ascribed to lack of chest auscultation skills.

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Hebrew Terms versus Recommended Terminology

Table 1 lists (i) the standard and phonetic forms of the *correct* Hebrew terms used by the three groups; (ii) their accepted meaning in English; and (iii) the recommended English terminology. The Hebrew terms describing the normal breath sound, wheezes, crackles, stridor, and pleural friction rub corresponded to

the recommended terminology in English. Although they were considered correct for the purpose of classifying the sounds, the Hebrew terms meaning "vesicular" and "alveolar", "crepitation", "rale" and "friction" were not in conformity with the recommendations. The Hebrew terms for "vesicular" ("vesiculari") and "crepitation" ("crepitatziot") were simple adaptations of English terms, while the term for "stridor" was the very English term, spelled with Hebrew letters. **e-Table 1** in the e-supplement lists the 50 *incorrect* Hebrew terms used by the observers. Of these, 10 were used to classify the normal breath sound, 11 to classify the wheezes, 11 to classify the crackles, 8 to classify the stridor, and 10 to classify the pleural friction rub.

Influence of Language and Auscultation Skills

Overall, 687 sessions of sound identification were carried out [Table 2]. In 598, for each sound, the observers provided terms in the two languages. In 89 they provided terms in one language only, and in 28 they provided no terms in either language. Percent rates of subjects in the 4 groups described above were as follows:

- 1. Caregivers with both language and auscultation skills: n=321 (46.7%)
- 2. Caregivers with language skills but no auscultation skills: n=265 (38.6%)
- 3. Caregivers with single-language skills and auscultation skills: n=43 (6.3%)
- 4. Caregivers with neither language nor auscultation skills: n=58 (8.4%)

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Discussion

In his original work, Laennec used the terms rale and rhonchus interchangeably to denote all classes of adventitious sounds [1]. Successive translations — first into English, then into other languages — and redefinitions of the original terminology gave different meanings to these terms, starting a confusion that persists to this day. To overcome this drawback, recommendations for use of a standardised terminology in the English language were made by the *Ad Hoc* committees of scientific societies [3-5]. The terms — simple and precise — are based on the physics of the sounds, without assumptions about their mechanism of generation or site of production [3-5]. In a population of caregivers working in Israel, we compared the Hebrew terms used to classify 5 common sounds with the (a) recommended terminology and (b) the English terms used by the same caregivers to classify the same sounds.

Overall, the observers' ability to classify the sounds in Hebrew was high for the wheezes and stridor, fair for the crackles, and low for the normal breath sounds and the pleural friction rub. The three groups of caregivers performed similarly in classifying all sounds but the stridor, for which staff physicians and residents performed better than the medical students. Additionally, staff physicians performed better than the other two groups in classifying the pleural friction rub; however, their absolute performance was too low to be considered clinically meaningful. As a whole, this evaluation was similar to that of the English terms reported in the first study **[11]**. This finding is interesting because in theory one

could expect the caregivers to perform better in their working language than in English.

Of 3 correct Hebrew terms used to classify the normal breath sound, just one, – "normal sound" — corresponded to the recommended term in English. The other two, "vesiculari" and "buyit" - meaning respectively "vesicular" and "alveolar" are deemed inappropriate, as they convey the incorrect assumption that the normal sound originates from the *entrance of air into and out of the air-cells of* the lungs [1]. Incidentally, although the *exact* locale and mode of production of the normal breath sound has not been established, there is evidence to support the view that it has a double origin: the lobar and segmental airways for the inspiratory component and a more central source for the expiratory component

[12, 13]

Consistent with our previous study [11] the observers used a single Hebrew term to classify the wheezes. This term, "tziftzufim," is the classic Hebrew term for this sound. This homogeneous description is interesting. Indeed, the term "wheezing" has been in use long before Laennec's invention of the stethoscope, while "wheeze", as used nowadays, corresponds to the "rale sibilant sec" described by Laennec [14]. We speculate that since this sound has been traditionally attributed to a single mechanism — airway obstruction — over the years, a single term was used to describe it. Consequently, the translation from the source language to other languages was kept relatively uniform, as found in the present study.

The term "stridor" — from the Latin *stridere* (harsh, shrill or creaking noise) describes the high-pitched, musical sound produced by turbulent flow passing through a narrowed segment of the upper respiratory tract [15]. In similarity with Page 13 of 21

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the classification of the wheezes, all correct raters used a single term. However, instead of the Hebrew term "שרנוק" ("shirnuk") they used the term "stridor" itself, spelled in the Hebrew alphabet. This peculiar choice suggests that, rather than searching for a suitable terminology, the caregivers preferred a term familiar to them. This finding is similar to that reported in a recent survey of lung sound nomenclature carried out in 34 European countries, which showed that caregivers from *all* the countries - representing 29 languages, five of which had non-Latin alphabets – spelled the term "stridor" verbatim in all languages but Greek [16]. With two categories – "fine" and "coarse" – "crackles" can be defined as brief, non-musical, explosive, adventitious sounds [17, 18]. In this study, the Hebrew equivalent of "crackles" was used correctly just once, by a medical student. Of the other acceptable terms, "crepitatziot" is solely an adaptation of "crepitations", while "hirhurim" is the classical Hebrew term for "rales". It should be noted that both these terms are considered superfluous or inadequate: "crepitations" because it merely means high-pitched crackling and "rales" because as stated above, it was originally a generic term applied to every variety of adventitious pulmonary sound [1]. Incidentally, the accepted mechanism of production of fine crackles is not the presence of secretions in the airways, but the sudden opening of airways in deflated territories of the lung as observed, for instance, in restrictive lung disorders (e.g. Interstitial Lung Disease) [17-19].

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Of the presented sounds, the pleural friction rub is probably the less well-studied. Purportedly, it is produced by the sudden release of tangential tension in a superficial portion of the lung momentarily arrested in its sliding movement by a frictional force between the two pleurae [**18**]. The tiny group of observers who

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correctly classified this sound used 2 terms (vs. 4 terms in the English part of the survey [**11**]): pleural and friction, alone or in combination.

A novel information provided by this study is that poor skills in chest auscultation largely surpassed deficient language skills as a cause of incorrect lung sound classification. While almost 90% of participants were found to be skilled in the two languages, rather surprisingly, less than half were found to be equally skilled in auscultation. Consistent with our previous study [11] this finding further illustrates the fact that use of recommended terminology is meaningful only among observers with good auscultation skills. In fact, observer agreement on a wrong classification can be detrimental to the patients, as it may lead to unnecessary and expensive investigations as well as improper treatment [11].

To our knowledge, there is no research similar to this study that can provide data for comparison. Searching the literature, we found that the importance of the correct understanding of the original terminology by caregivers working in LOTE has been examined only peripherally. For instance, in a survey of seven European countries, lack of familiarity with the English nomenclature was invoked to explain the lower agreement of Russian and Dutch practitioners to classify crackles and wheezes from video-recordings [**20**]. Also, in the European terminology survey quoted above, the terms used across the countries were generally non-uniform, some countries having their own terminology, others simply adopting the English terminology [**16**].

This study has limitations. First, for the sake of feasibility, we recruited caregivers from the same hospital, which may limit the generalizability of the findings. However, compensation was provided by their heterogeneity in terms of clinical

and educational background. Second, we did not investigate all adventitious sounds. For simplicity, we stuck to the commonest ones, intentionally excluding others such as, for instance, the rhonchus or the squawk, whose inclusion might have further hampered the observers' ability to classify the sounds.

In summary, the Hebrew terms used to classify common lung sounds corresponded only partly to the recommended terminology. Many Hebrew terms were adaptations or transliterations of ancient, inappropriate English terms, such as "vesicular sound" and "crepitations". Of practical importance, a high proportion of matched Hebrew/English terms were incorrect. These data support the conclusion that poor auscultation skills surpassed poor language skills as a factor hampering the meaningful transfer of the recommended terminology to LOTE (Hebrew). By consequence, improved education in chest auscultation should be the main prerequisite for the successful dissemination of the recommended terminology. Based on our results, some suggestions can be made to encourage the widespread use of a standardised lung sound terminology in non-native English speaking countries. Countries with a high knowledge of English could simply adopt the recommended terminology verbatim. Alternatively, countries with a lower knowledge of English could opt for the translation of the recommended terms; however, this must be done properly, by professionals skilled in both the source (English) and the target (LOTE) language. Finally, if resources for translation are not available, transliteration of the recommended terms seems a viable option. Adopted spontaneously by many observers in this study, transliteration requires no special language skills and can be performed in any language, including those with non-Latin alphabets. For its simplicity, it should be given consideration by the medical societies of all concerned countries.

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Competing Interest

None declared

Author contribution

Original idea/study design: A. Bohadana

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Grant application: G. Izbicki

Drafting of the manuscript: A. Bohadana

Responsibility for data: AB; AR; HA; AJ; GK and GI are guarantors for the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Critical revision of the manuscript: All authors

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Table 1. Comparison Between Hebrew Terms Used and Recommended EnglishTerms

Audio	Recommended Terminology		Hebrew Terms		Fr	equency of Use
sample	in the English Language	Standard	Phonetic	English Meaning	n	By Group
#1	Normal breath sound	נשימה נורמלית	Neshima normalit	Normal breathing	8	SP=1 R= 3; MS=4
		נשימה וסקולרית	Neshima vesicularit	Vesicular breathing	2	SP=2
		נשימה בועית	Neshima buit	"Alveolar" breathing	10	SP=3 R= 4; MS=3
# 2	Wheezes	צפצופים	Tziftzufim	Wheezes	116	SP=24 R=51 MS=41
#3	Crackles	קריפיטציות	Crepitatziot	Crepitations	42	SP=12 R=17 MS=13
		פיצפוצים	Pitzputzim	Crackles	1	MS=1
		חרחורים	Hirhurim	Rales	42	SP=5 R=22 MS=15
#4	Stridor ¹	² סטרידור	Stridor	Stridor	110	SP=26 R=55 MS=29
#5	Pleural friction rub ¹	שפשוף פלאורלי	Shifshuf pleurali	Pleural rubbing	10	SP=8 R=1 MS=1
		פריקשן	Friction	Friction	1	R=1

1. Suggested [2]

2. The correct term - שִׁרְנוּק (shirnuk) - was not used by any rater.

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Table 2: Language and Auscultation	n Skills Among Caregivers	From the Three Groups
Table 2. Language and Auscultation	i Skills Alliong Calegivers	rion the rinee droups

	Observers providing classification in the two languages (n=598)					roviding classif only (n	= 89)	e language	
	Identical terms in the two languages (n=586)		Different terms in the two languages, (n=12)		English (n=27)		5	/ (n=62)	No
True classification	Both terms correct ¹ (n=321)	Both terms Incorrect ² (n=265)	English correct ³ (n=8)	Hebrew correct ³ (n=4)	Correct ³ (n=14)	Incorrect ⁴ (n=13)	2021. Correct Mnloa (n=17)oa	Incorrect ⁴ (n=45)	classification in either language (n=28)
# 1 Normal	19 (5.9%)	106 (40.0%)	1	0	0	3	ded from	10	3
# 2 Wheeze	110 (34.3%)	19 (7.2%)	2	1	2	0	http://bm	4	0
					(Jjop		
# 3 Crackle	76 (23.7%)	34 (12.8%)	3	3	4	2	njopen.bmj 6	8	7
							.com/		
# 4 Stridor	105 (32.7%)	17 (6.4%)	2	0	5	3	5 ⁹	2	4
						∇h	April		
# 5 PFR	11 (3.4%)	89 (33.6%)	0	0	3	5	19, 20 0	21	14

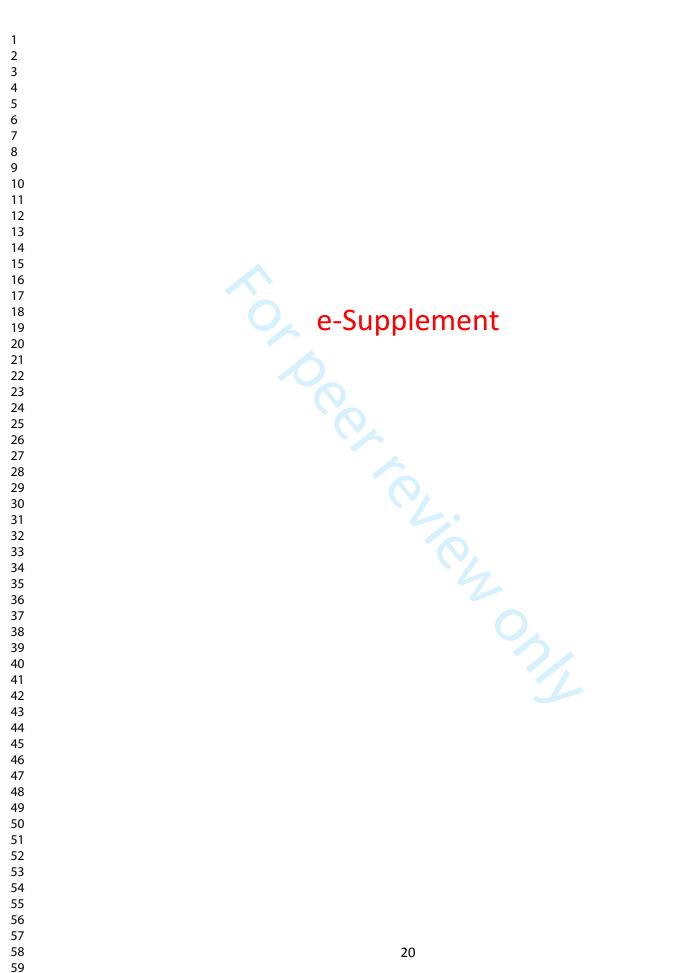
1. Caregivers with both language and auscultation skills: n=321 (46.7%)

2. Caregivers with language skills but no auscultation skills: n=265 (38.6%)

3. Caregivers with single-language skills and auscultation skills: n=43 (6.3%)

4. Caregivers with neither language nor auscultation skills: n=58 (8.4%)

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Sample	Standard Hebrew				
		Phonetic Hebrew	English Meaning	<u>n</u>	Repartition by group
#1	קריפיטציות	Crepitatziot	Crepitations	60	SP=10 R=37 MS=13
N=10	חרחורים	Hirhurim	Rales	32	SP=3 R=11 MS=18
	נשימה ברונכיאלית	Neshima bron <u>ch</u> ialit	Bronchial breathing	18	SP=8 R=6 MS=4
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	MS=1
	ירידה עם חירחורים עדינים	Yerida im hirhurim adinim	Diminished with fine rales	1	MS=1
	שפשוף	Shifshuf	Friction	1	SP=1
	ציפצופים	Tziftzufim	Wheezes	1	MS=1
	שיפשוף פליאורלי	Shifshuf pleurali	Pleural friction	1	SP=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	רישרוש של פלוירה	Rishrush shel pleura	Pleural friction	1	SP=1
#2	סטרידור	Stridor	Stridor	4	SP=1 R=2 MS=1
N=11	חרחורים	Hirhurim	Rales	1	MS=1
	קרפיטציות	Crepitatziot	Crepitations	1	MS=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	SP=1 R=1
	חיכוך פליאורלי	Chikuch pleurali	Pleural friction	1	SP=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	8	SP=2 R=5 MS=1
	גניחות	Genihot	Groan	1	R=1
	אנחות	Anahot	Sigh	1	SP=1
	אוושה סיסטולית	Ivsha sistolit	Systolic murmur	4	R=3 MS=1
	מיוזיקלי	Musicali	Musical	1	R=1
	קולות ממקור עליון	Kolot mimakor elion	Sounds from upper source	1	MS=1
#3	נשימה ברונכיאלית/תקינה	Neshima bronchialit tekina	Normal bronchial br.	19	SP=7 R=10 MS=2
N=11	נורמלי	Normali	Normal	6	SP=1 R=2 MS=3
	נחירות	Nehirot	Snoring	1	SP=1
	כניסת אוויר מופחתת	Knissat avir mufhetet	Diminished air entry	1	MS=1
	כניסת אוויר מופחתת,רשרו	Knissat avir mufhetet im	Diminished air entry with	1	MS=1
	אקספירטורי	rishrush expiratoy	expiratory rustle		
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	R=1 MS=1
	ציפצופים	Tziftzufim	Wheezes	2	R=1 MS=1
	נשימה בועית	Neshima buyit	Vesicular breathing	9	SP=3 R=3 MS=3
	כניסת אוויר ירודה	Knisat avir yeruda	Decrease air entry	2	R=1 MS=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	R=1
	פקעיים	Pkaim	Crepitations	1	MS=1
#4	ציפצופים	Tziftzufim	Wheezes	14	SP=1 R=5 MS=8
N=8	<u>וויזינג</u>	Wizing	Wheezing	1	MS=1
	השתנקות	Histankut	Gasping	1	MS=1
	שריקה	Shirika	Whistle/wheezing	1	MS=1
	דיבור	Dibur	Talk	1	MS=1 MS=1
	ברונכוספאזם	Bronchospasm	Bronchospasm	1	MS=1 MS=1
	בו ונפוסטאום מיוזיקל	Musical	Musical	1	R=1
	מיוז קן חריקה/שרנוק	Harika	Creak/Friction	1	MS=1
#5 PFR	ריילס	Rales	Rales	1	SP=1
N=10	קריפיטציות	Crepitatziot	Crepitations	13	SP=4 R=5 MS=4
11-10	קו יפיסציות חרחורים	Hirhurim	Rales	78	SP=15 R=36 MS=27
			Decrease air entry	_	
	ירידה בכניסת אוויר	Yerida beknissat avir		1	MS=1
	ציפצופים	Tziftzufim	Wheezes	1	R=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	12	R=9 MS=3
	שיפשוף פריקרדיאלי	Shifshuf pericardiali	Pericardial friction rub	1	MS=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	איוושה	Ivsha	Murmur	1	R=1

"Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Cross-Sectional Survey of Staff Physicians, Residents and Medical Students."

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BMJ Open

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2 3		
4	1	Tuesday, January 26, 2021
5 6	2	CLEAN COPY
7 8	3	
9	4	Influence of Language Skills on the Choice of Terms Used to
10 11	5	Describe Lung Sounds in a Language Other Than English: A
12 13	6	Cross-Sectional Survey of Staff Physicians, Residents and
14		Medical Students
15 16	7	Medical Students
17	8	Abraham Rohadanal: Hava Azulail: Amir Jariqui ² : Goorgo Kalak ² : Ariol Rokach ¹ :
18 19	9 10	Abraham Bohadana ¹ ; Hava Azulai ¹ ; Amir Jarjoui ² ; George Kalak ² ; Ariel Rokach ¹ ; and Gabriel Izbicki ¹
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24 25	14	with the Hadassah School of Medicine, Hebrew University of Jerusalem
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28	16	with the Hadassah School of Medicine, Hebrew University of Jerusalem
29 30	17	
31	18	
32 33	19	Short Title: Lung sound terminology in a language other than English (LOTE)
34	20	
35 36	21	Word count: 3155
37	22	
38 39	23	
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43 44	26 27	
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1 2		
3	1	Abstract
4 5	2	Introduction: The value of chest auscultation would be enhanced by the use of a
6 7	3	standardised terminology. To that end, the recommended English terminology
8	4	must be transferred to a language other than English (LOTE) without distortion.
9 10	5	Objective: To examine the transfer to Hebrew – taken as a model of LOTE - of the
11	6	recommended terminology in English.
12 13	7	Design/Setting: Cross-sectional study; university-based hospital.
14 15	8	Participants: 143 caregivers, including 31 staff physicians, 65 residents, and 47
16	9	medical students
17 18	10	Methods: Observers provided uninstructed descriptions in Hebrew and English of
19 20	10	audio-recordings of 5 common sounds, namely, normal breath sound (NBS);
20 21	12	wheezes; crackles; stridor and pleural friction rub (PFR).
22 23	13	Outcomes: a) Rates of correct/incorrect classification; b) Correspondence
24	13 14	between Hebrew and recommended English terms; c) Language and auscultation
25 26	14	skills, assessed by crossing the responses in the two languages with each other
27	16	and with the classification of the audio-recordings validated by computer analysis.
28 29	17	Results: Range (%) of correct rating was as follows: NBS=11.3%-20%;
30 31	17	Wheezes=79.7-87.2%; Crackles=58.6-69.8%; Stridor=67.4-96.3%; and PFR=2.7-
32	19	28.6%. Of 60 Hebrew terms, 11 were correct and 5 matched the recommended
33 34	20	English terms. Many Hebrew terms were adaptations or transliterations of
35	21	inadequate English terms. Of 687 evaluations, good dual- and single-language
36 37	22	skills were found in 586 (85.3%) and 41 (6%), respectively. However, in 325
38	23	(47.3%) evaluations good language skills were associated with poor auscultation
39 40	24	skills.
41	25	Conclusion: Poor auscultation skills surpassed poor language skills as a factor
42 43	26	hampering the transfer to Hebrew (LOTE) of the recommended English
44 45	27	terminology. Improved education in auscultation emerged as the main factor to
45 46	28	promote the use of standardised lung sound terminology. Using our data, a
47 48	29	strategy was devised to encourage the use of standardised terminology in non-
49	30	native English speaking countries.
50 51	31	Word count: 273
52	32	Key words: lung sound terminology; lung auscultation; observer variability;
53		

⁵⁴ 33 language skills; language other than English; LOTE

1

2		
3 4	1	Strengths and Limitations of this Study
5 6	2	> To our knowledge, this is the first study to examine the transfer to LOTE of
7 8	3	the recommended lung sound terminology in English.
9 10 11 12	4	True sound classification was validated by computer-based sound analysis.
12 13 14	5	Participants were from the same hospital – which tends to limit the study
15 16	6	generalisability – but had different clinical and educational background.
17 18	7	Use of more complex sounds (e.g. rhonchus, squawk) might have further
19 20	8	hampered the observers' ability to classify the sounds.
21 22 23	9	numpered the observers dointy to classify the sounds.
24 25	10	
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41 42 43	18	
44 45	19	
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INTRODUCTION

Lung auscultation has been a traditional part of the chest examination since the invention of the stethoscope [1]. Whilst no other method equals auscultation in providing quick, cost-effective, and easily obtained, relevant information about the respiratory system, its value is limited by the confused terminology [2]. Even though recommendations on terminology have been developed [3-5] significant variation in the terms used to describe the sounds persists among health professionals [6-11].

To examine this variation, we invited staff physicians, residents, and medical students working in a university-based hospital in Israel, to spontaneously classify a set of common lung sounds presented to them in audio-recordings. They were asked to classify the sounds successively in English and Hebrew, taken as a model of a language other than English (LOTE). Different aspects of the survey were highlighted in two companion papers. The first, published recently, found that poor auscultation skills were the main factor influencing the choice of English terminology [11]. The second, reported herein, examined the influence of language skills on the transfer to a LOTE (i.e. Hebrew) of the terminology recommended currently by scientific societies [3-5]. This aspect has practical importance. First, between-language differences hamper communication in teaching and in meaningful exchanges of auscultation findings between clinicians and researchers from different countries [10]. Moreover, they can cause divergent interpretations of the same sound even by caregivers from the same country. This study aimed to compare the Hebrew terms used by our observers, with those recommended currently [3-5] and with the English terms they used to classify the same sounds previously [11].

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1 MATERIALS AND METHODS

Recruitment of the raters

From February 2017 through March 2018 we recruited 143 caregivers, including
31 staff physicians (SP), 65 residents (R) and 47 medical students (MS) working at
Shaare Zedek Medical Center, affiliated with the Hebrew University of Jerusalem
[11]. Participants were informed about the study by word-of-mouth. The study
was submitted to the hospital's Ethics Committee and approved with advice that
no informed consent was required.

9 Questionnaire

Upon arrival, participants were invited to complete an anonymous questionnaire
 on background information, including demographics, medical status, years of
 practice, and specialty. We avoided questions likely to facilitate participants'
 identification.

14 Presentation of the sounds

Next, the participants were invited to listen through loudspeakers to the audiofiles of 5 common lung sounds stored in a computer placed in a silent room. The
sound files were taken from a set of processed files in the Movie.mp4 format,
which were deemed to be clean and devoid of artifacts, as required for an article
published previously [2]. The following sounds were presented, in that order: 1.
Normal breath sound; 2. Wheezes; 3. Crackles; 4. Stridor and 5. Pleural Friction
Rub.

22 Classification of the sound files

The observers were asked to classify the sounds successively in English and Hebrew in the order they were played (i.e. 1-5). No pre-established list of sound

nomenclature was given in either language, and the observers were asked to describe the sounds in a "free-form" format, with their own words. No sonograms, waveform analysis or clinical information were provided to substantiate the nature of the sounds. To attempt to compensate for the lack of clinical context, the observers were informed that all recordings started at the onset of inspiration. Additionally, the site of recording of each sound was indicated on a diagram, as follows: 1. Normal breath sound: posterior left basal lung region at a point situated in the scapular line, 3 cm below the angle of scapula; 2. Wheezes: anterior right upper lung zone at the intersection of the mid-clavicular line and the 2nd intercostal space; 3. Inspiratory crackles: right posterior basal region at the intersection of the scapular line and a point situated 3 cm below the angle of scapula; 4. Stridor: over the trachea, 2 cm above the supra-sternal notch; and 5. Pleural friction rub: left axillary region at the intersection of the mid-axillary line and the 5th intercostal space.

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15 Correct versus Incorrect Sound Classification

The ability to correctly identify the sounds was determined for each sound file by comparing the observers' response with the true classification i.e. clinical classification validated by computer analysis [**2**]. A rating was considered correct if a recommended term or an accepted synonym was used to describe the sound (term use ascribed to preference). The use of any incorrect term was ascribed to lack of skills on chest auscultation.

22 Language and Auscultation Skills

The ability to correctly classify the sounds depends both on language skills and auscultation skills. For each observer, we crossed the sound classification in Hebrew with the corresponding classification English, performed previously by

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the same observers [11]. Four classes of combined skills were identified, as follows: 1. Dual-language skills and good auscultation skills. Use of accepted terms in the two languages to correctly classify a sound (e.g. use of the English term "wheeze" and the Hebrew term "tziftzufim" to classify the wheezes of sound sample # 2). 2. Dual-language skills and poor auscultation skills. Use of accepted, corresponding terms in the two languages to *incorrectly* classify a sound (e.g. use of the English term "pleural friction rub" and its *corresponding* Hebrew equivalent "shifshuf pleurali" to wrongly classify the wheezes of sound sample # 2). 3. Single-language skills and good auscultation skills. Use of a correct term in one language and an *incorrect* (or no) term in the other language to correctly classify a sound (e.g. use of the English term wheeze coupled with, say, the *incorrect* Hebrew term "hirhurim" to classify the wheezes of sound sample # 2}. 4. Poor language skills and poor auscultation skills. Use of different, incorrect terms in the two languages to classify a sound (e.g. use of "crackle" and "shifshuf pleurali" to classify the wheezes of sound sample # 2).

5 16 Patient and Public Involvement

17 Due to the nature of this study, patients and the public were not involved in the 18 study design and research analysis.

19 Data Analysis

Baseline characteristics are presented as mean (SD) and proportions. For each audio sample, the difference in the proportion of correct vs. incorrect rating was tested using the Chi square test; a p < 0.05 was considered significant.

RESULTS

1

2 3

4

5	-	Characteristics of participants
6 7	2	Characteristics of participants
8 9	3	Participants' mean (SD) age was as follows: SP= 48.4 yrs. (10.4); R=32.5 yrs. (3.5),
10 11	4	and MS=28.4 yrs. (4.5). Overall, 17 (54.8%) staff physicians declared more than
12 13	5	20-year experience with auscultation; in turn, 60 (92%) residents and 47 (100%)
14 15	6	medical students declared < 5-year experience.
16 17 18	7	Language profile and specialty of staff physicians
19 20 21	8	The first language of 27 SPs who provided responses to this question were:
22 23	9	Hebrew, n=16, English, n=4, Arabic, n=2, French, n=2, Russian, n=2, and
23 24 25	10	Portuguese, n=1. All respondents reported the learning of unspecified versions of
26 27	11	the lung sound terminology in English and Hebrew (n=23). The repartition by
28 29	12	specialty was as follows: Pulmonology, n=7; Pediatrics, n=6; Internal Medicine,
30 31	13	n=4; Cardiology, n=2; Oncology, n=2; Geriatrics, n=1; Hematology, n=1;
32 33	14	Emergency medicine, n=1; Rheumatology, n=1; Palliative care, n=1 and Family
34 35	15	medicine, n=1. Twenty four SPs practiced medicine in both English and Hebrew,
36 37 38	16	while 3 practiced only in Hebrew.
39 40	17	Correct Hebrew Terms versus Recommended English Terminology
41 42	18	Table 1 lists (i) the standard and phonetic forms of the correct Hebrew terms used
43 44	19	by the three groups; (ii) their meaning in English; and (iii) the corresponding
45 46	20	recommended English terminology. Overall, the rates of correct identification
47 48	21	were high for the wheeze (SP=80%; R=79.7%; MS=87.2%; [p=.944]) and the stridor
49 50	22	(SP=96.3%; R=90.2%; MS=67.4%; [p=.544]), fair for the crackles (SP=58.6%;
51 52	23	R=67.2%; MS=69.8%; [p=.899]) and low for the normal lung sound (SP=20%;
53 54		
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- R=11.3%; MS=15.5%; [p=.624]) and the pleural friction rub (SP=28.6%; R=3.6%; MS=2.7% [p=.002]). Preference versus Poor Auscultation Skill Altogether, the observers used 60 Hebrew terms to classify the 5 sounds; of these 11 (18.3%) were correct, being therefore ascribed to preferences regarding terminology, while 49 (81.7%) were incorrect, being ascribed to lack of chest auscultation skills. Correct terms by group Sample sound #1 (Normal breath sound): Of 137 participants classifying this file, 20 correctly classified it as normal. Of 3 Hebrew terms used, only 1 corresponded to the recommended English term "normal breath sound".
- Sample sound # 2 (Wheezes): Of 141 participants classifying this file, 116 (82.3%)
 used a single Hebrew term "Tziftzufim" corresponding to the recommended
 English term "Wheeze".
- Sample sound # 3 (*Crackles*): Of 130 participants classifying this file, 86 (66.2%)
 used 4 Hebrew terms to correctly classify it as crackles. However, only 1 term –
 "Pitzputzim" corresponded to the recommended English term crackle.
- Sample sound # 4 (Stridor): Of 131 participants classifying this sound, 110 (84%)
 correctly classified it by means of a Hebrew transliteration of the recommended
 English term "stridor".
- Sample sound # 5 (*Pleural friction rub*): Of 121 participants classifying this sample,
 - 11 (9.1%) correctly classified it as pleural friction rub. They used 2 terms, of which
 - ²³ "Shifshuf Pleurali", meaning "Pleural rubbing", was used on 10 occasions.
 - 24 Incorrect Hebrew Terms

The 49 incorrect Hebrew terms are listed in the **e-Table 1**. Of these, 10 were used to classify the normal breath sound, 11 to classify the wheezes, 10 to classify the crackles, 8 to classify the stridor, and 10 to classify the pleural friction rub.

4 Transfer to Hebrew of the English Terminology

Identification of 5 sounds by 143 subjects would have resulted in 715 instances of identification. However, on 28 occasions the observers declined to classify a sound in either language, thus giving a total of 687 (96%) instances of sound identification. On 597 (87%) of these occasions, the observers provided terms in the two languages for all sounds, while on 90 (12.9%) they provided terms in one language only. The combination of language skills and auscultation skills, obtained by crossing the correct and incorrect responses in the 687 sessions, is given in detail in Table 2. The resulting combination of language skills and auscultation skills was a follows:

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14 1. Dual-language skills *and* good auscultation skills. n=321 (46.7%)

15 2. Dual-language skills *and* poor auscultation skills n=265 (38.6%).

3. Single-language skills and good auscultation skills. n=41 (6.0%)

4. Poor language skills and poor auscultation skills. n=60 (8.7%)

DISCUSSION

In his original work, Laennec used the terms "rale" and "rhonchus" interchangeably, to denote all classes of adventitious sounds [1]. Successive translations — first into English, then into other languages — and redefinitions of the original terminology gave different meanings to these terms, starting a confusion that persists to this day. To overcome this drawback, recommendations for use of a standardised terminology in the English language were made by the Ad Hoc committees of scientific societies [3-5]. The recommended terms -simple and precise — are based on the physics of the sounds, without assumptions about their mechanism of generation or site of production [3-5]. In a population of caregivers working in Israel, we compared the Hebrew terms used to classify 5 common sounds with: (a) the recommended terminology in English and; (b) the terms used by the same caregivers to classify the same sounds in the English language.

In similarity with our companion study [11] the observers' ability to classify the sounds in Hebrew was high for the wheezes and the stridor, fair for the crackles, and low for the normal breath sounds and the pleural friction rub, with the three groups of caregivers performing similarly in classifying all sounds. Even though the staff physicians performed better than the other groups in classifying the pleural friction rub, the overall performance of the three groups was too low to be considered clinically meaningful. This similarity of performance regarding the two languages is interesting, because, in theory, one could expect the caregivers to perform better in their working language - Hebrew - than in English.

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Of 3 correct Hebrew terms used to classify sound file # 1, just one corresponded to the recommended term "Normal breath sound" in English. The other two, "Vesiculari" and "Buyit" — meaning respectively "Vesicular" and "Alveolar" — are deemed inappropriate as they convey the incorrect assumption that the normal sound originates from the *entrance of air into and out of the air-cells of the lungs* [1]. As a quick aside, although the *exact* locale and mode of production of the normal breath sound has not been established, there is evidence to support the view that it has a double origin: the lobar and segmental airways for the inspiratory component, and a more central source for the expiratory component [12, 13]

Consistent with our previous study [11] all observers used the classic Hebrew term "Tziftzufim" to classify the wheezes. This homogeneous description is interesting. Indeed, the term "Wheezing" has been in use long before Laennec's invention of the stethoscope, while "Wheeze", as used nowadays, corresponds to the "Rale sibilant sec" described by Laennec [14]. We speculate that the traditional attribution of this sound to a single mechanism – airway obstruction – might have contributed for the use of a single term to describe it. Consequently, the translation from the source language (i.e. English) to other languages was kept relatively uniform, as found in the present study.

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The term "Stridor" — from the Latin *stridere* (harsh, shrill or creaking noise) —
describes the high-pitched, musical sound produced by turbulent flow passing
through a narrowed segment of the upper respiratory tract [15]. In similarity with
the classification of the wheezes, all correct raters used a single term. However,
instead of the Hebrew term "שׁרְמָוּק" ("Shirnuk") they used the term "Stridor" itself,
spelled in the Hebrew alphabet. This peculiar choice suggests that, rather than

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searching for a suitable terminology, the caregivers preferred a term familiar to
them. This finding is similar to that reported in a recent survey of lung sound
nomenclature carried out in 34 European countries, which showed that caregivers
from *all* the countries - representing 29 languages of which 5 had non-Latin
alphabets – spelled the term "Stridor" verbatim in all languages but Greek [16].

With two categories – "Fine" and "Coarse" – crackles can be defined as brief, non-musical, explosive, adventitious sounds [17, 18]. In this study, the Hebrew equivalent of "Crackles" was used just once, by a medical student. Of the other acceptable terms, "Crepitatziot" is solely an adaptation of "Crepitations", while "Hirhurim" is the classical Hebrew term for "Rales". It should be noted that both these terms are considered superfluous or inadequate: "Crepitations" because it merely means high-pitched crackling, and "Rales" because, as stated above, it was originally a generic term applied to every variety of adventitious pulmonary sound [1]. Incidentally, the accepted mechanism of production of fine crackles is not the presence of secretions in the airways, but the sudden opening of airways in deflated territories of the lung as observed in restrictive lung disorders (e.g. Interstitial Lung Disease) [17-19].

Of the presented sounds, the pleural friction rub is probably the less well-studied. Purportedly, it is produced by the sudden release of tangential tension in a superficial portion of the lung momentarily arrested in its sliding movement by a frictional force between the two pleurae [**18**]. The tiny group of observers who correctly classified this sound used 2 terms (vs. 4 terms in the English part of the survey [**11**]): pleural and friction, alone or in combination. Page 15 of 25

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A novel information provided by this study is that poor skills in chest auscultation largely surpassed deficient language skills as a cause of incorrect lung sound classification. Of 90% of participants found to have good language skills, 50% had poor auscultation skills. Consistent with our previous study [11] this finding further illustrates the fact that the use of recommended terminology is meaningful only among observers with good auscultation skills. In fact, observer agreement on a wrong classification can be detrimental to the patients, as it may lead to unnecessary and expensive investigations as well as improper treatment [11].

Most of our staff physicians practiced medicine in both Hebrew and English. This aspect has clinical relevance. The ability of nonnative English-speaking doctors to communicate with patients in English is now considered a core-competency. Consistent with its status of global lingua franca, the English language is the universal means of communication between people with different native languages. In this context, ensuring the similarity of terminology between English and a LOTE is important, as language-concordant health care contributes to prevent expensive tests and poor patient follow-up.

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To our knowledge, there is no research similar to this study that can provide data for comparison. Searching the literature, we found that the importance of the correct understanding of the original English terminology by caregivers working in a LOTE has been examined only peripherally. For instance, in a survey of seven European countries, lack of familiarity with the English nomenclature was invoked to explain the lower agreement of Russian and Dutch practitioners to classify crackles and wheezes from video-recordings [20]. Also, in the European terminology survey quoted above, the terms used across the countries were

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generally non-uniform, some countries having their own terminology, others
simply adopting the English terminology [16].

This study has limitations. First, for the sake of feasibility, we recruited caregivers from the same hospital, which may limit the generalisability of the findings. However, compensation was provided by their heterogeneity in terms of clinical and educational background. Second, we did not investigate all adventitious sounds. For simplicity, we stuck to the commonest ones, intentionally excluding more complex sounds such as, for instance, the rhonchus or the squawk, whose inclusion might have further hampered the observers' ability to classify the sounds. Finally, the experimental conditions were not representative of those in clinical practice. The study design prevented the participants to auscultate all over the chest, at will, or to command the respiratory maneuvers, which may have altered outcomes compared with real-life. However, to avoid more detrimental biases we were forced to standardize the study conditions across participants.

15 CONCLUSION

In this study, the Hebrew terms used to classify common lung sounds corresponded only partly to the recommended terminology. Many Hebrew terms were adaptations or transliterations of inappropriate English terms (e.g. "Vesicular sound", "Crepitations"). Noticeably, a high proportion of matched Hebrew/English terms was incorrect. These data support the conclusion that poor auscultation skills surpassed poor language skills as a factor hampering the meaningful transfer of the recommended terminology to a LOTE (Hebrew). In this context, improved education in chest auscultation should be the main prerequisite for the successful dissemination of the recommended terminology.

Based on our results, some suggestions can be made to encourage the widespread use of a standardised lung sound terminology in non-native English speaking countries. Countries with a high knowledge of English could simply adopt the recommended English terminology verbatim. Alternatively, countries with a lower knowledge of English could opt for the translation of the recommended terms by professionals skilled in both the source (English) and the target (LOTE) language. Finally, if resources for translation are not available, transliteration of the recommended terms seems a viable option. Adopted spontaneously by many observers in this study, transliteration requires no special language skills and can be performed in any language, including those with non-Latin alphabets. For its simplicity, it should be given consideration by the medical societies of all concerned countries.

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Table 1. Comparison Of Hebrew Terms With Recommended English Terms UsedBy Three Groups of Caregivers to Classify Five Lung Sounds

	Recommended				Fr	equency of Use
Audio						I
sample	in the English					By Group
	Language	Standard	Phonetic	English Meaning	n	
#1	Normal breath sound	נשימה נורמלית	Neshima			
			normalit	Normal breathing	8	SP=1 R= 3; MS=4
		נשימה וסקולרית	Neshima	Vesicular		
			vesicularit	breathing ³	2	SP=2
		נשימה בועית	Neshima buit	"Alveolar"		
				breathing ³	10	SP=3 R= 4; MS=3
# 2	Wheezes	צפצופים	Tziftzufim	Wheezes		SP=24 R=51
					116	MS=41
#3	Crackles	קריפיטציות	Crepitatziot			SP=12 R=17
				Crepitations ³	42	MS=13
		פיצפוצים	Pitzputzim	Crackles	1	MS=1
		פקעיים	Pkaim	Fine Crepitations ³	1	MS=1
		חרחורים				SP=5 R=22
			Hirhurim	Rales	42	MS=15
#4	Stridor ¹	² סטרידור		Stridor		SP=26 R=55
			Stridor		110	MS=29
# 5	Pleural friction rub ¹	שפשוף פלאורלי	Shifshuf pleurali	Pleural rubbing ³	10	SP=8 R=1 MS=1
		פריקשן	Friction	Friction	1	R=1

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1. Term suggested [ref # 2]

2. The correct term - שִׁרְנוּק (shirnuk) - was not used by any rater.

3. Term considered correct but nor recommended

SP= Staff physicians; R= Residents; MS= Medical students

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BMJ Open **Table 2**: Language and Auscultation Skills Among Staff Physicians, Residents and Medical Students: English versus on 26 **Terminology in LOTE**

		Possible	Number of Se	essions of Sour	nd Identificati	on for All Obs	servers (n=7	Maro 7₽5)	
	Observers providing classification in the			Observers providing classification in one					
		two languages				language or		OW	
	Similar term			erms in the	English	(n=27)	Hebre	v ह ू(n=63)	No
	languages	1	•	ages (n=11)		1		Idec	classification
	Both terms	Both terms	English	Hebrew				1 frc	in either
Sound	correct ¹	Incorrect ²	correct ³	correct ³	Correct ³	Incorrect ⁴	Correct ³	∃Incorrect⁴	language
Classification	(n=321)	(n=265)	(n=7)	(n=4)	(n=14)	(n=13)	(n=16)	(n=47)	(n=28)
# 1 Normal	19 (5.9%)	106 (40.0%)	1	0	0	3	1		3
								pen n	
# 2 Wheeze	110 (34.3%)	19 (7.2%)	2	1	2	0	5	.bmi 4	0
# 3 Crackle	77 (24.0%)	34 (12.8%)	2	3	4	2	6	8 8 0m/ on Apr	7
# 4 Stridor	104 (32.4%)	17 (6.4%)	2	0	5	3	4	11 19, <u>2024</u>	4
# 5 PFR	11 (3.4%)	89 (33.6%)	0	0	3	5	0	24 by guest. Protected by copyright	14
1. Dual-languag	e skills <i>and</i> good	d auscultation s	kills. n=321 (46.7%)				est.	
2. Dual-languag	e skills <i>and</i> poor	r auscultation s	kills n=265 (3	8.6%).				Pro	
3. Single-langu	age skills and go	od auscultation	skills. n=41 ((6.0%)				tect	
4. Poor languag	e skills and poor	auscultation s	kills. n=60 (8.	7%)				fed	
								by c	
								оруг	
				21				ight.	

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e-Table 1. Incorrect Hebrew Terms Used b	v the Three Groups

Sound Sample	Standard Hebrew	Phonetic Hebrew	English Meaning	n	Repartition by group
#1 NBS	קריפיטציות	Crepitatziot	Crepitations	60	SP=10 R=37 MS=13
N=10	חרחורים	Hirhurim	Rales	32	SP=3 R=11 MS=18
	נשימה ברונכיאלית	Neshima bron ch ialit	Bronchial breathing	18	SP=8 R=6 MS=4
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	MS=1
	ירידה עם חירחורים עדינים	Yerida im hirhurim adinim	Diminished with fine rales	1	MS=1
	שפשוף	Shifshuf	Friction	1	SP=1
	ציפצופים	Tziftzufim	Wheezes	1	MS=1
	שיפשוף פליאורלי	Shifshuf pleurali	Pleural friction	1	SP=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	רישרוש של פלוירה	Rishrush shel pleura	Pleural friction	1	SP=1
#2 Wheeze	סטרידור	Stridor	Stridor	4	SP=1 R=2 MS=1
N=11	חרחורים	Hirhurim	Rales	1	MS=1
14 11	קרפיטציות	Crepitatziot	Crepitations	1	MS=1
	ַקו פּ טַצַ ווּנ נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	SP=1 R=1
	חיכוך פליאורלי		Pleural friction	1	SP=1 K=1
	-	Chikuch pleurali			-
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	8	SP=2 R=5 MS=1
	גניחות	Genihot	Groan	1	R=1
	אנחות	Anahot	Sigh	1	SP=1
	אוושה סיסטולית	lvsha sistolit	Systolic murmur	4	R=3 MS=1
	מיוזיקלי	Musicali	Musical	1	R=1
	קולות ממקור עליון	Kolot mimakor elion	Sounds from upper source	1	MS=1
#3 Crackle	נשימה ברונכיאלית/תקינה	Neshima bronchialit tekina	Normal bronchial br.	19	SP=7 R=10 MS=2
N=10	נורמלי	Normali	Normal	6	SP=1 R=2 MS=3
	נחירות	Nehirot	Snoring	1	SP=1
	כניסת אוויר מופחתת	Knissat avir mufhetet	Diminished air entry	1	MS=1
	כניסת אוויר מופחתת,רשרו	Knissat avir mufhetet im	Diminished air entry with	1	MS=1
	אקספירטורי	rishrush expiratoy	expiratory rustle		
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	R=1 MS=1
	ציפצופים	Tziftzufim	Wheezes	2	R=1 MS=1
	נשימה בועית	Neshima buyit	Vesicular breathing	9	SP=3 R=3 MS=3
	כניסת אוויר ירודה	Knisat avir yeruda	Decrease air entry	2	R=1 MS=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	R=1
#4 Stridor	ציפצופים	Tziftzufim	Wheezes	14	SP=1 R=5 MS=8
N=8	וויזינג	Wizing	Wheezing	1	MS=1
	השתנקות	Histankut	Gasping	1	MS=1
	שריקה	Shirika	Whistle/wheezing	1	MS=1
	דיבור	Dibur	Talk	1	MS=1
	ברונכוספאזם	Bronchospasm	Bronchospasm	1	MS=1
	מיוזיקל	Musical	Musical	1	R=1
	 חריקה/שרנוק	Harika	Creak/Friction	1	MS=1
#5 PFR	ריילס	Rales	Rales	1	SP=1
N=10	קריפיטציות	Crepitatziot	Crepitations	13	SP=4 R=5 MS=4
11-10	קו פ סצ ות חרחורים	Hirhurim	Rales	78	SP=15 R=36 MS=27
				_	
	ירידה בכניסת אוויר	Yerida beknissat avir	Decrease air entry	1	MS=1
	ציפצופים	Tziftzufim	Wheezes	1	R=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	12	R=9 MS=3
	שיפשוף פריקרדיאלי	Shifshuf pericardiali	Pericardial friction rub	1	MS=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	איוושה	lvsha	Murmur	1	R=1
	גודש ריאתי	Godesh reiati	Pulmonary congestion	1	R=1

NBS: Normal breath sound; PFR: Pleural friction rub SP= Staff physicians; R= Residents; MS= Medical students

Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Cross-Sectional Survey of Staff Physicians, Residents and Medical Students A. Bohadana et al.

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract
		page 1
		(b) Provide in the abstract an informative and balanced summary of what was done
		and what was found page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported page 4
Objectives	3	State specific objectives, including any prespecified hypotheses page 4
Methods		
Study design	4	Present key elements of study design early in the paper page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment,
		exposure, follow-up, and data collection page 5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of
		participants NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
		modifiers. Give diagnostic criteria, if applicable NA
Data sources/	8*	For each variable of interest, give sources of data and details of methods of
measurement		assessment (measurement). Describe comparability of assessment methods if there i
		more than one group NA
Bias	9	Describe any efforts to address potential sources of bias NA
Study size	10	Explain how the study size was arrived at NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,
		describe which groupings were chosen and why NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		page 7
		(b) Describe any methods used to examine subgroups and interactions NA
		(c) Explain how missing data were addressed NA
		(<i>d</i>) If applicable, describe analytical methods taking account of sampling strategy
		NA
		(\underline{e}) Describe any sensitivity analyses NA
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study,
Participants	13*	
Participants	13*	eligible, examined for eligibility, confirmed eligible, included in the study,
Participants	13*	eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed NA (b) Give reasons for non-participation at each stage NA
Participants Descriptive data	13*	eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed NA

		(b) Indicate number of participants with missing data for each variable of interest
		NA
Outcome data	15*	Report numbers of outcome events or summary measures NA
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included NA
		(b) Report category boundaries when continuous variables were categorized NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a
		meaningful time period NA
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions, and
		sensitivity analyses NA
Discussion		
Key results	18	Summarise key results with reference to study objectives page 12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or
		imprecision. Discuss both direction and magnitude of any potential bias page 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations,
		multiplicity of analyses, results from similar studies, and other relevant evidence
		page 15
Generalisability	21	Discuss the generalisability (external validity) of the study results page 15
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if
		applicable, for the original study on which the present article is based page 18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

"Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Cross-Sectional Survey of Staff Physicians, Residents and Medical Students."

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BMJ Open

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19	10	Abraham Bohadana ¹ ; Hava Azulai ¹ ; Amir Jarjoui ² ; George Kalak ² ; Ariel Rokach ¹ ;
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2 3 4	1	Fax: 972-02-666-6772
5 6	2	Abstract
7	3	Introduction: The value of chest auscultation would be enhanced by the use of a
8 9	4	standardised terminology. To that end, the recommended English terminology
10	5	must be transferred to a language other than English (LOTE) without distortion.
11 12	6	Objective: To examine the transfer to Hebrew – taken as a model of LOTE - of the
13 14	7	recommended terminology in English.
15 16	8	Design/Setting: Cross-sectional study; university-based hospital.
17	9	Participants: 143 caregivers, including 31 staff physicians, 65 residents, and 47
18 19	10	medical students
20	11	Methods: Observers provided uninstructed descriptions in Hebrew and English of
21 22	12	audio-recordings of 5 common sounds, namely, normal breath sound (NBS);
23 24	13	wheezes; crackles; stridor and pleural friction rub (PFR).
25	14	Outcomes: a) Rates of correct/incorrect classification; b) Correspondence
26 27	15	between Hebrew and recommended English terms; c) Language and auscultation
28	16	skills, assessed by crossing the responses in the two languages with each other
29 30	17	and with the classification of the audio-recordings validated by computer analysis.
31 32	18	Results: Range (%) of correct rating was as follows: NBS=11.3%-20%;
32 33	19	Wheezes=79.7-87.2%; Crackles=58.6-69.8%; Stridor=67.4-96.3%; and PFR=2.7-
34	20	28.6%. Of 60 Hebrew terms, 11 were correct and 5 matched the recommended
35 36	21	English terms. Many Hebrew terms were adaptations or transliterations of
37	22	inadequate English terms. Of 687 evaluations, good dual- and single-language
38 39	23	skills were found in 586 (85.3%) and 41 (6%), respectively. However, in 325
40	24	(47.3%) evaluations good language skills were associated with poor auscultation
41 42	25	skills.
43	26	Conclusion: Poor auscultation skills surpassed poor language skills as a factor
44 45	27	hampering the transfer to Hebrew (LOTE) of the recommended English
46	28	terminology. Improved education in auscultation emerged as the main factor to
47 48	29	promote the use of standardised lung sound terminology. Using our data, a
40 49	30	strategy was devised to encourage the use of standardised terminology in non-

Word count: 273 32

native English speaking countries.

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3 4	1	Key words: lung sound terminology; lung auscultation; observer variability;
5 6	2	language skills; language other than English; LOTE
7 8	3	Strengths and Limitations of this Study
9 10	4	To our knowledge, this is the first study to examine the transfer to LOTE of
11 12	5	the recommended lung sound terminology in English.
13 14 15	6	True sound classification was validated by computer-based sound analysis.
16 17 18	7	Participants were from the same hospital – which tends to limit the study
19 20	8	generalisability – but had different clinical and educational background.
21 22	9	Use of more complex sounds (e.g. rhonchus, squawk) might have further
23 24 25	10	hampered the observers' ability to classify the sounds.
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INTRODUCTION

Lung auscultation has been a traditional part of the chest examination since the invention of the stethoscope [1]. Whilst no other method equals auscultation in providing quick, cost-effective, and easily obtained, relevant information about the respiratory system, its value is limited by the confused terminology [2]. Even though recommendations on terminology have been developed [3-5] significant variation in the terms used to describe the sounds persists among health professionals [6-11].

To examine this variation, we invited staff physicians, residents, and medical students working in a university-based hospital in Israel, to spontaneously classify a set of common lung sounds presented to them in audio-recordings. They were asked to classify the sounds successively in English and Hebrew, taken as a model of a language other than English (LOTE). Different aspects of the survey were highlighted in two companion papers. The first, published recently, found that poor auscultation skills were the main factor influencing the choice of English terminology [11]. The second, reported herein, examined the influence of language skills on the transfer to a LOTE (i.e. Hebrew) of the terminology recommended currently by scientific societies [3-5]. This aspect has practical importance. First, between-language differences hamper communication in teaching and in meaningful exchanges of auscultation findings between clinicians and researchers from different countries [10]. Moreover, they can cause divergent interpretations of the same sound even by caregivers from the same country. This study aimed to compare the Hebrew terms used by our observers, with those recommended currently [3-5] and with the English terms they used to classify the same sounds previously [11].

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1 MATERIALS AND METHODS

Recruitment of the raters

From February 2017 through March 2018 we recruited 143 caregivers, including
31 staff physicians (SP), 65 residents (R) and 47 medical students (MS) working at
Shaare Zedek Medical Center, affiliated with the Hebrew University of Jerusalem
[11]. Participants were informed about the study by word-of-mouth. The study
was submitted to the hospital's Ethics Committee and approved with advice that
no informed consent was required.

9 Questionnaire

10 Upon arrival, participants were invited to complete an anonymous questionnaire 11 on background information, including demographics, medical status, years of 12 practice, and specialty. We avoided questions likely to facilitate participants' 13 identification.

14 Presentation of the sounds

Next, the participants were invited to listen through loudspeakers to the audiofiles of 5 common lung sounds stored in a computer placed in a silent room. The
sound files were taken from a set of processed files in the Movie.mp4 format,
which were deemed to be clean and devoid of artifacts, as required for an article
published previously [2]. The following sounds were presented, in that order: 1.
Normal breath sound; 2. Wheezes; 3. Crackles; 4. Stridor and 5. Pleural Friction
Rub.

22 Classification of the sound files

The observers were asked to classify the sounds successively in English and Hebrew in the order they were played (i.e. 1-5). No pre-established list of sound

nomenclature was given in either language, and the observers were asked to describe the sounds in a "free-form" format, with their own words. No sonograms, waveform analysis or clinical information were provided to substantiate the nature of the sounds. To attempt to compensate for the lack of clinical context, the observers were informed that all recordings started at the onset of inspiration. Additionally, the site of recording of each sound was indicated on a diagram, as follows: 1. Normal breath sound: posterior left basal lung region at a point situated in the scapular line, 3 cm below the angle of scapula; 2. Wheezes: anterior right upper lung zone at the intersection of the mid-clavicular line and the 2nd intercostal space; 3. Inspiratory crackles: right posterior basal region at the intersection of the scapular line and a point situated 3 cm below the angle of scapula; 4. Stridor: over the trachea, 2 cm above the supra-sternal notch; and 5. Pleural friction rub: left axillary region at the intersection of the mid-axillary line and the 5th intercostal space.

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15 Correct versus Incorrect Sound Classification

The ability to correctly identify the sounds was determined for each sound file by comparing the observers' response with the true classification i.e. clinical classification validated by computer analysis [**2**]. In this process, an expert selected a segment of the recorded normal sounds that was free of artifacts. A rating was considered correct if a recommended term or an accepted synonym was used to describe the sound (term use ascribed to preference). The use of any incorrect term was ascribed to lack of skills on chest auscultation.

23 Language and Auscultation Skills

The ability to correctly classify the sounds depends both on language skills and auscultation skills. For each observer, we crossed the sound classification in

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Hebrew with the corresponding classification English, performed previously by the same observers [11]. Four classes of combined skills were identified, as follows: 1. Dual-language skills and good auscultation skills. Use of accepted terms in the two languages to correctly classify a sound (e.g. use of the English term "wheeze" and the Hebrew term "tziftzufim" to classify the wheezes of sound sample # 2). 2. Dual-language skills and poor auscultation skills. Use of accepted, corresponding terms in the two languages to *incorrectly* classify a sound (e.g. use of the English term "pleural friction rub" and its *corresponding* Hebrew equivalent "shifshuf pleurali" to wrongly classify the wheezes of sound sample # 2). 3. Single-language skills and good auscultation skills. Use of a correct term in one language and an *incorrect* (or no) term in the other language to correctly classify a sound (e.g. use of the English term wheeze coupled with, say, the *incorrect* Hebrew term "hirhurim" to classify the wheezes of sound sample # 2}. 4. Poor language skills and poor auscultation skills. Use of different, incorrect terms in the two languages to classify a sound (e.g. use of "crackle" and "shifshuf pleurali" to classify the wheezes of sound sample # 2).

17 Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting ordissemination of this study.

20 Data Analysis

Baseline characteristics are presented as mean (SD) and proportions. For each
audio sample, the difference in the proportion of correct vs. incorrect rating was
tested using the Chi square test; a p < 0.05 was considered significant.

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RESULTS Characteristics of participants Participants' mean (SD) age was as follows: SP= 48.4 yrs. (10.4); R=32.5 yrs. (3.5), and MS=28.4 yrs. (4.5). Overall, 17 (54.8%) staff physicians declared more than 20-year experience with auscultation; in turn, 60 (92%) residents and 47 (100%) medical students declared < 5-year experience. Language profile and specialty of staff physicians The first language of 27 SPs who provided responses to this question were: Hebrew, n=16, English, n=4, Arabic, n=2, French, n=2, Russian, n=2, and Portuguese, n=1. All respondents reported the learning of unspecified versions of the lung sound terminology in English and Hebrew (n=23). The repartition by specialty was as follows: Pulmonology, n=7; Pediatrics, n=6; Internal Medicine, n=4; Cardiology, n=2; Oncology, n=2; Geriatrics, n=1; Hematology, n=1; Emergency medicine, n=1; Rheumatology, n=1; Palliative care, n=1 and Family medicine, n=1. Twenty four SPs practiced medicine in both English and Hebrew, while 3 practiced only in Hebrew. Correct Hebrew Terms versus Recommended English Terminology **Table 1** lists (i) the standard and phonetic forms of the correct Hebrew terms used by the three groups; (ii) their meaning in English; and (iii) the corresponding recommended English terminology. Overall, the rates of correct identification were high for the wheeze (SP=80%; R=79.7%; MS=87.2%; [p=.944]) and the stridor (SP=96.3%; R=90.2%; MS=67.4%; [p=.544]), fair for the crackles (SP=58.6%; R=67.2%; MS=69.8%; [p=.899]) and low for the normal lung sound (SP=20%;

- R=11.3%; MS=15.5%; [p=.624]) and the pleural friction rub (SP=28.6%; R=3.6%; MS=2.7% [p=.002]). Preference versus Poor Auscultation Skill Altogether, the observers used 60 Hebrew terms to classify the 5 sounds; of these 11 (18.3%) were correct, being therefore ascribed to preferences regarding terminology, while 49 (81.7%) were incorrect, being ascribed to lack of chest auscultation skills. Correct terms by group Sample sound #1 (Normal breath sound): Of 137 participants classifying this file, 20 correctly classified it as normal. Of 3 Hebrew terms used, only 1 corresponded to the recommended English term "normal breath sound". **Sample sound # 2** (*Wheezes*): Of **141** participants classifying this file, 116 (82.3%) used a single Hebrew term - "Tziftzufim" - corresponding to the recommended
- ³¹
 ³² 14 English term "Wheeze".

- Sample sound # 3 (*Crackles*): Of 130 participants classifying this file, 86 (66.2%)
 used 4 Hebrew terms to correctly classify it as crackles. However, only 1 term –
 "Pitzputzim" corresponded to the recommended English term crackle.
- Sample sound # 4 (Stridor): Of 131 participants classifying this sound, 110 (84%)
 correctly classified it by means of a Hebrew transliteration of the recommended
 English term "stridor".
- Sample sound # 5 (*Pleural friction rub*): Of 121 participants classifying this sample,
 - 11 (9.1%) correctly classified it as pleural friction rub. They used 2 terms, of which
 - ²³ "Shifshuf Pleurali", meaning "Pleural rubbing", was used on 10 occasions.
 - 24 Incorrect Hebrew Terms

The 49 incorrect Hebrew terms are listed in the **e-Table 1**. Of these, 10 were used to classify the normal breath sound, 11 to classify the wheezes, 10 to classify the crackles, 8 to classify the stridor, and 10 to classify the pleural friction rub.

4 Transfer to Hebrew of the English Terminology

Identification of 5 sounds by 143 subjects would have resulted in 715 instances of identification. However, on 28 occasions the observers declined to classify a sound in either language, thus giving a total of 687 (96%) instances of sound identification. On 597 (87%) of these occasions, the observers provided terms in the two languages for all sounds, while on 90 (12.9%) they provided terms in one language only. The combination of language skills and auscultation skills, obtained by crossing the correct and incorrect responses in the 687 sessions, is given in detail in Table 2. The resulting combination of language skills and auscultation skills was a follows:

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14 1. Dual-language skills *and* good auscultation skills. n=321 (46.7%)

15 2. Dual-language skills *and* poor auscultation skills n=265 (38.6%).

3. Single-language skills and good auscultation skills. n=41 (6.0%)

4. Poor language skills and poor auscultation skills. n=60 (8.7%)

DISCUSSION

In his original work, Laennec used the terms "rale" and "rhonchus" interchangeably, to denote all classes of adventitious sounds [1]. Successive translations — first into English, then into other languages — and redefinitions of the original terminology gave different meanings to these terms, starting a confusion that persists to this day. To overcome this drawback, recommendations for use of a standardised terminology in the English language were made by the Ad Hoc committees of scientific societies [3-5]. The recommended terms -simple and precise — are based on the physics of the sounds, without assumptions about their mechanism of generation or site of production [3-5]. In a population of caregivers working in Israel, we compared the Hebrew terms used to classify 5 common sounds with: (a) the recommended terminology in English and; (b) the terms used by the same caregivers to classify the same sounds in the English language.

In similarity with our companion study [11] the observers' ability to classify the sounds in Hebrew was high for the wheezes and the stridor, fair for the crackles, and low for the normal breath sounds and the pleural friction rub, with the three groups of caregivers performing similarly in classifying all sounds. Even though the staff physicians performed better than the other groups in classifying the pleural friction rub, the overall performance of the three groups was too low to be considered clinically meaningful. This similarity of performance regarding the two languages is interesting, because, in theory, one could expect the caregivers to perform better in their working language - Hebrew - than in English.

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Of 3 correct Hebrew terms used to classify sound file # 1, just one corresponded to the recommended term "Normal breath sound" in English. The other two, "Vesiculari" and "Buyit" — meaning respectively "Vesicular" and "Alveolar" — are deemed inappropriate as they convey the incorrect assumption that the normal sound originates from the *entrance of air into and out of the air-cells of the lungs* [1]. As a quick aside, although the *exact* locale and mode of production of the normal breath sound has not been established, there is evidence to support the view that it has a double origin: the lobar and segmental airways for the inspiratory component, and a more central source for the expiratory component [12, 13]

Consistent with our previous study [11] all observers used the classic Hebrew term "Tziftzufim" to classify the wheezes. This homogeneous description is interesting. Indeed, the term "Wheezing" has been in use long before Laennec's invention of the stethoscope, while "Wheeze", as used nowadays, corresponds to the "Rale sibilant sec" described by Laennec [14]. We speculate that the traditional attribution of this sound to a single mechanism – airway obstruction – might have contributed for the use of a single term to describe it. Consequently, the translation from the source language (i.e. English) to other languages was kept relatively uniform, as found in the present study.

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The term "Stridor" — from the Latin *stridere* (harsh, shrill or creaking noise) —
describes the high-pitched, musical sound produced by turbulent flow passing
through a narrowed segment of the upper respiratory tract [15]. In similarity with
the classification of the wheezes, all correct raters used a single term. However,
instead of the Hebrew term "שִׁרְמָהַ" ("Shirnuk") they used the term "Stridor" itself,
spelled in the Hebrew alphabet. This peculiar choice suggests that, rather than

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searching for a suitable terminology, the caregivers preferred a term familiar to
them. This finding is similar to that reported in a recent survey of lung sound
nomenclature carried out in 34 European countries, which showed that caregivers
from *all* the countries - representing 29 languages of which 5 had non-Latin
alphabets – spelled the term "Stridor" verbatim in all languages but Greek [16].

With two categories – "Fine" and "Coarse" – crackles can be defined as brief, non-musical, explosive, adventitious sounds [17, 18]. In this study, the Hebrew equivalent of "Crackles" was used just once, by a medical student. Of the other acceptable terms, "Crepitatziot" is solely an adaptation of "Crepitations", while "Hirhurim" is the classical Hebrew term for "Rales". It should be noted that both these terms are considered superfluous or inadequate: "Crepitations" because it merely means high-pitched crackling, and "Rales" because, as stated above, it was originally a generic term applied to every variety of adventitious pulmonary sound [1]. Incidentally, the accepted mechanism of production of fine crackles is not the presence of secretions in the airways, but the sudden opening of airways in deflated territories of the lung as observed in restrictive lung disorders (e.g. Interstitial Lung Disease) [17-19].

Of the presented sounds, the pleural friction rub is probably the less well-studied. Purportedly, it is produced by the sudden release of tangential tension in a superficial portion of the lung momentarily arrested in its sliding movement by a frictional force between the two pleurae [**18**]. The tiny group of observers who correctly classified this sound used 2 terms (vs. 4 terms in the English part of the survey [**11**]): pleural and friction, alone or in combination.

A novel information provided by this study is that poor skills in chest auscultation largely surpassed deficient language skills as a cause of incorrect lung sound classification. Of 90% of participants found to have good language skills, 50% had poor auscultation skills. Consistent with our previous study [11] this finding further illustrates the fact that the use of recommended terminology is meaningful only among observers with good auscultation skills. In fact, observer agreement on a wrong classification can be detrimental to the patients, as it may lead to unnecessary and expensive investigations as well as improper treatment [11].

Most of our staff physicians practiced medicine in both Hebrew and English. This aspect has clinical relevance. The ability of nonnative English-speaking doctors to communicate with patients in English is now considered a core-competency. Consistent with its status of global lingua franca, the English language is the universal means of communication between people with different native languages. In this context, ensuring the similarity of terminology between English and a LOTE is important, as language-concordant health care contributes to prevent expensive tests and poor patient follow-up.

To our knowledge, there is no research similar to this study that can provide data for comparison. Searching the literature, we found that the importance of the correct understanding of the original English terminology by caregivers working in a LOTE has been examined only peripherally. For instance, in a survey of seven European countries, lack of familiarity with the English nomenclature was invoked to explain the lower agreement of Russian and Dutch practitioners to classify crackles and wheezes from video-recordings [20]. Also, in the European terminology survey quoted above, the terms used across the countries were

generally non-uniform, some countries having their own terminology, others
simply adopting the English terminology [16].

This study has limitations. First, for the sake of feasibility, we recruited caregivers from the same hospital, which may limit the generalisability of the findings. However, compensation was provided by their heterogeneity in terms of clinical and educational background. Second, we did not investigate all adventitious sounds. For simplicity, we stuck to the commonest ones, intentionally excluding more complex sounds such as, for instance, the rhonchus or the squawk, whose inclusion might have further hampered the observers' ability to classify the sounds. Finally, the experimental conditions were not representative of those in clinical practice. The study design prevented the participants to auscultate all over the chest, at will, or to command the respiratory maneuvers, which may have altered outcomes compared with real-life. However, to avoid more detrimental biases we were forced to standardize the study conditions across participants.

CONCLUSION

In this study, the Hebrew terms used to classify common lung sounds corresponded only partly to the recommended terminology. Many Hebrew terms were adaptations or transliterations of inappropriate English terms (e.g. "Vesicular sound", "Crepitations"). Noticeably, a high proportion of matched Hebrew/English terms was incorrect. These data support the conclusion that poor auscultation skills surpassed poor language skills as a factor hampering the meaningful transfer of the recommended terminology to a LOTE (Hebrew). In this context, improved education in chest auscultation should be the main prerequisite for the successful dissemination of the recommended terminology.

Based on our results, some suggestions can be made to encourage the widespread use of a standardised lung sound terminology in non-native English speaking countries. Countries with a high knowledge of English could simply adopt the recommended English terminology verbatim. Alternatively, countries with a lower knowledge of English could opt for the translation of the recommended terms by professionals skilled in both the source (English) and the target (LOTE) language. Finally, if resources for translation are not available, transliteration of the recommended terms seems a viable option. Adopted spontaneously by many observers in this study, transliteration requires no special language skills and can be performed in any language, including those with non-Latin alphabets. For its simplicity, it should be given consideration by the medical societies of all concerned countries.

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Table 1. Comparison Of Hebrew Terms With Recommended English Terms UsedBy Three Groups of Caregivers to Classify Five Lung Sounds

A	Recommended				Fr	equency of Use
Audio	Terminology		Hebrew Terms			
sample	in the English		-			By Group
	Language	Standard	Phonetic	English Meaning	n	
#1	Normal breath sound	נשימה נורמלית	Neshima			
			normalit	Normal breathing	8	SP=1 R= 3; MS=4
		נשימה וסקולרית	Neshima	Vesicular		
			vesicularit	breathing ³	2	SP=2
		נשימה בועית	Neshima buit	"Alveolar"		
				breathing ³	10	SP=3 R= 4; MS=3
# 2	Wheezes	צפצופים	Tziftzufim	Wheezes		SP=24 R=51
					116	MS=41
#3	Crackles	קריפיטציות	Crepitatziot			SP=12 R=17
				Crepitations ³	42	MS=13
		פיצפוצים	Pitzputzim	Crackles	1	MS=1
		פקעיים	Pkaim	Fine Crepitations ³	1	MS=1
		חרחורים				SP=5 R=22
			Hirhurim	Rales	42	MS=15
#4	Stridor ¹	² סטרידור		Stridor		SP=26 R=55
			Stridor		110	MS=29
# 5	Pleural friction rub ¹	שפשוף פלאורלי	Shifshuf pleurali	Pleural rubbing ³	10	SP=8 R=1 MS=1
		פריקשן	Friction	Friction	1	R=1

1. Term suggested [ref # 2]

2. The correct term - שָׁרְנוּק (shirnuk) - was not used by any rater.

3. Term considered correct but nor recommended

SP= Staff physicians; R= Residents; MS= Medical students

BMJ Open BMJ Open Table 2: Language and Auscultation Skills Among Staff Physicians, Residents and Medical Students: English versus Terminology in LOTE

		Possible	Number of Se	essions of Sour	nd Identificatio	on for All Obs	ervers (n=	5 9 7115)	
	Observ	vers providing cla two languages	assification in			rs providing o language or	classificatio	2	
	Similar terms languages	s in the two	Different to	erms in the ages (n=11)	English				No classification
Sound Classification	Both terms correct ¹ (n=321)	Both terms Incorrect ² (n=265)	English correct ³ (n=7)	Hebrew correct ³ (n=4)	Correct ³ (n=14)	Incorrect ⁴ (n=13)	Correct ³ (n=16)	⊇ alncorrect⁴ ✿ (n=47)	in either language (n=28)
# 1 Normal	19 (5.9%)	106 (40.0%)	1	0	0	3	1	from 10	3
# 2 Wheeze	110 (34.3%)	19 (7.2%)	2	1	2	0	5	tp://bmjope	0
# 3 Crackle	77 (24.0%)	34 (12.8%)	2	3	4	2	6	n.bmj.comv	7
# 4 Stridor	104 (32.4%)	17 (6.4%)	2	0	5	3	4	V on April	4
# 5 PFR	11 (3.4%)	89 (33.6%)	0	0	3	5	0	19,	14
1. Dual-languag 2. Dual-languag 3. Single-languag	ge skills <i>and</i> good ge skills <i>and</i> poor age skills and goo ge skills and poor	l auscultation s auscultation sl od auscultation	kills n=265 (3 skills. n=41 (8.6%). (6.0%)				20 20 24 by guest. Protected by copyright.	

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Sound					
Sample	Standard Hebrew	Phonetic Hebrew	English Meaning	n	Repartition by grou
#1 NBS	קריפיטציות	Crepitatziot	Crepitations	60	SP=10 R=37 MS=13
N=10	חרחורים	Hirhurim	Rales	32	SP=3 R=11 MS=18
	נשימה ברונכיאלית	Neshima bron <u>ch</u> ialit	Bronchial breathing	18	SP=8 R=6 MS=4
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	MS=1
	ירידה עם חירחורים עדינים	Yerida im hirhurim adinim	Diminished with fine rales	1	MS=1
	שפשוף	Shifshuf	Friction	1	SP=1
	ציפצופים	Tziftzufim	Wheezes	1	MS=1
	שיפשוף פליאורלי	Shifshuf pleurali	Pleural friction	1	SP=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	רישרוש של פלוירה	Rishrush shel pleura	Pleural friction	1	SP=1
#2 Wheeze	סטרידור	Stridor	Stridor	4	SP=1 R=2 MS=1
N=11	חרחורים	Hirhurim	Rales	1	MS=1
-	קרפיטציות	Crepitatziot	Crepitations	1	MS=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	SP=1 R=1
	חיכוך פליאורלי	Chikuch pleurali	Pleural friction	1	SP=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	8	SP=2 R=5 MS=1
	גניחות	Genihot	Groan	1	R=1
	אנחות	Anahot	Sigh	1	SP=1
	אנוווונ אוושה סיסטולית	Ivsha sistolit	Systolic murmur	4	R=3 MS=1
	אוושרו ט טטא ת מיוזיקלי	Musicali	Musical	1	R=1
	מיוויקרי קולות ממקור עליון	Kolot mimakor elion	Sounds from upper source	1	MS=1 MS=1
#3 Crackle	נשימה ברונכיאלית/תקינה	Neshima bronchialit tekina	Normal bronchial br.	19	SP=7 R=10 MS=2
M=10	נשינוה בחונכיאליונקינה נורמלי	Normali		6	
N=10			Normal	1	SP=1 R=2 MS=3 SP=1
	נחירות בנוסת עשיב מוססתת	Nehirot	Snoring		-
	כניסת אוויר מופחתת	Knissat avir mufhetet	Diminished air entry	1	MS=1
	כניסת אוויר מופחתת,רשרו אדספובנייבו	Knissat avir mufhetet im	Diminished air entry with	1	MS=1
	אקספירטורי	rishrush expiratoy	expiratory rustle	-	
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	R=1 MS=1
	ציפצופים	Tziftzufim	Wheezes	2	R=1 MS=1
	נשימה בועית	Neshima buyit	Vesicular breathing	9	SP=3 R=3 MS=3
	כניסת אוויר ירודה	Knisat avir yeruda	Decrease air entry	2	R=1 MS=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	R=1
#4 Stridor	ציפצופים	Tziftzufim	Wheezes	14	SP=1 R=5 MS=8
N=8	וויזינג	Wizing	Wheezing	1	MS=1
	השתנקות	Histankut	Gasping	1	MS=1
	שריקה	Shirika	Whistle/wheezing	1	MS=1
	דיבור	Dibur	Talk	1	MS=1
	ברונכוספאזם	Bronchospasm	Bronchospasm	1	MS=1
	מיוזיקל	Musical	Musical	1	R=1
	חריקה/שרנוק	Harika	Creak/Friction	1	MS=1
#5 PFR	ריילס	Rales	Rales	1	SP=1
N=10	קריפיטציות	Crepitatziot	Crepitations	13	SP=4 R=5 MS=4
	חרחורים	Hirhurim	Rales	78	SP=15 R=36 MS=27
	ירידה בכניסת אוויר	Yerida beknissat avir	Decrease air entry	1	MS=1
	ציפצופים	Tziftzufim	Wheezes	1	R=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	12	R=9 MS=3
	שיפשוף פריקרדיאלי	Shifshuf pericardiali	Pericardial friction rub	1	MS=1
	פיכפוך .	Pichpuch	Bubbling	1	R=1
	איוושה	Ivsha	Murmur	1	R=1
	גודש ריאתי	Godesh reiati	Pulmonary congestion	1	R=1

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students

Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Cross-Sectional Survey of Staff Physicians, Residents and Medical Students A. Bohadana et al.

STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract page 1
		(b) Provide in the abstract an informative and balanced summary of what was done
		and what was found page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported page 4
Objectives	3	State specific objectives, including any prespecified hypotheses page 4
Methods		
Study design	4	Present key elements of study design early in the paper page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection page 5
Participants	6	(<i>a</i>) Give the eligibility criteria, and the sources and methods of selection of participants NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable NA
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group NA
Bias	9	Describe any efforts to address potential sources of bias NA
Study size	10	Explain how the study size was arrived at NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why NA
Statistical methods	12	(<i>a</i>) Describe all statistical methods, including those used to control for confounding page 7
		(b) Describe any methods used to examine subgroups and interactions NA
		(c) Explain how missing data were addressed NA
		(<i>d</i>) If applicable, describe analytical methods taking account of sampling strategy
		NA
		(e) Describe any sensitivity analyses NA
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
		eligible, examined for eligibility, confirmed eligible, included in the study,
		completing follow-up, and analysed NA
		(b) Give reasons for non-participation at each stage NA
		(c) Consider use of a flow diagram NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
		information on exposures and potential confounders NA

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		(b) Indicate number of participants with missing data for each variable of interest NA
Outcome data	15*	Report numbers of outcome events or summary measures NA
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included NA
		(b) Report category boundaries when continuous variables were categorized NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a
		meaningful time period NA
Other analyses	17	Report other analyses done-eg analyses of subgroups and interactions, and
		sensitivity analyses NA
Discussion		
Key results	18	Summarise key results with reference to study objectives page 12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or
		imprecision. Discuss both direction and magnitude of any potential bias page 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations,
		multiplicity of analyses, results from similar studies, and other relevant evidence
		page 15
Generalisability	21	Discuss the generalisability (external validity) of the study results page 15
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if
		applicable, for the original study on which the present article is based page 18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

"Influence of Language Skills on the Choice of Terms Used to Describe Lung Sounds in a Language Other Than English: A Cross-Sectional Survey of Staff Physicians, Residents and Medical Students."

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12 13	6	Describe Lung Sounds in a Language Other Than English: A
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15 16		Medical Students
17 18	8	Weulcal Students
10	9	Abrehene Debedenel Ubre Aculail, Amin Janiaui?, Cooree Kalal?, Arial Debedal.
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31 32	18	
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1 2		
2 3 4	1	Fax: 972-02-666-6772
5 6	2	Abstract
0 7	3	Introduction: The value of chest auscultation would be enhanced by the use of a
8 9	4	standardised terminology. To that end, the recommended English terminology
9 10 11	5	must be transferred to a language other than English (LOTE) without distortion.
12	6	Objective: To examine the transfer to Hebrew – taken as a model of LOTE - of the
13	7	recommended terminology in English.
14 15 16	8	Design/Setting: Cross-sectional study; university-based hospital.
17	9	Participants: 143 caregivers, including 31 staff physicians, 65 residents, and 47
18 19	10	medical students
20	11	Methods: Observers provided uninstructed descriptions in Hebrew and English of
21 22	11	audio-recordings of 5 common sounds, namely, normal breath sound (NBS);
22	12	wheezes; crackles; stridor and pleural friction rub (PFR).
24	13	
25 26	14	Outcomes: a) Rates of correct/incorrect classification; b) Correspondence
27	15	between Hebrew and recommended English terms; c) Language and auscultation
28 29	16	skills, assessed by crossing the responses in the two languages with each other
30	17	and with the classification of the audio-recordings validated by computer analysis.
31 32	18	Results: Range (%) of correct rating was as follows: NBS=11.3%-20%;
33	19	Wheezes=79.7-87.2%; Crackles=58.6-69.8%; Stridor=67.4-96.3%; and PFR=2.7-
34	20	28.6%. Of 60 Hebrew terms, 11 were correct and 5 matched the recommended
35 36	21	English terms. Many Hebrew terms were adaptations or transliterations of
37	22	inadequate English terms. Of 687 evaluations, good dual- and single-language
38 39	23	skills were found in 586 (85.3%) and 41 (6%), respectively. However, in 325
40	24	(47.3%) evaluations good language skills were associated with poor auscultation
41 42	25	skills.
42	26	Conclusion: Poor auscultation skills surpassed poor language skills as a factor
44	20	hampering the transfer to Hebrew (LOTE) of the recommended English
45 46	27	terminology. Improved education in auscultation emerged as the main factor to
47	28 29	promote the use of standardised lung sound terminology. Using our data, a
48 49	30	strategy was devised to encourage the use of standardised terminology in non-
	50	strates, mas devised to encourage the use of standardised terminology in non-

Word count: 273 32

native English speaking countries.

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3 4	1	Key words: lung sound terminology; lung auscultation; observer variability;
	2	language skills; language other than English; LOTE
7 8	3	Strengths and Limitations of this Study
9 10	4	To our knowledge, this is the first study to examine the transfer to LOTE of
11 12	5	the recommended lung sound terminology in English.
13 14 15	6	True sound classification was validated by computer-based sound analysis.
16 17 18	7	Participants were from the same hospital – which tends to limit the study
19 20	8	generalisability – but had different clinical and educational background.
21 22	9	Use of more complex sounds (e.g. rhonchus, squawk) might have further
23 24 25	10	hampered the observers' ability to classify the sounds.
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INTRODUCTION

Lung auscultation has been a traditional part of the chest examination since the invention of the stethoscope [1]. Whilst no other method equals auscultation in providing quick, cost-effective, and easily obtained, relevant information about the respiratory system, its value is limited by the confused terminology [2]. Even though recommendations on terminology have been developed [3-5] significant variation in the terms used to describe the sounds persists among health professionals [6-11].

To examine this variation, we invited staff physicians, residents, and medical students working in a university-based hospital in Israel, to spontaneously classify a set of common lung sounds presented to them in audio-recordings. They were asked to classify the sounds successively in English and Hebrew, taken as a model of a language other than English (LOTE). Different aspects of the survey were highlighted in two companion papers. The first, published recently, found that poor auscultation skills were the main factor influencing the choice of English terminology [11]. The second, reported herein, examined the influence of language skills on the transfer to a LOTE (i.e. Hebrew) of the terminology recommended currently by scientific societies [3-5]. This aspect has practical importance. First, between-language differences hamper communication in teaching and in meaningful exchanges of auscultation findings between clinicians and researchers from different countries [10]. Moreover, they can cause divergent interpretations of the same sound even by caregivers from the same country. This study aimed to compare the Hebrew terms used by our observers, with those recommended currently [3-5] and with the English terms they used to classify the same sounds previously [11].

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1 MATERIALS AND METHODS

2 Recruitment of the raters

From February 2017 through March 2018 we recruited 143 caregivers, including
31 staff physicians (SP), 65 residents (R) and 47 medical students (MS) working at
Shaare Zedek Medical Center, affiliated with the Hebrew University of Jerusalem
[11]. Participants were informed about the study by word-of-mouth. The "Helsinki
Committee" at Shaare Zedek Medical Center approved this study with a waiver of
informed consent.

9 Questionnaire

Upon arrival, participants were invited to complete an anonymous questionnaire
 on background information, including demographics, medical status, years of
 practice, and specialty. We avoided questions likely to facilitate participants'
 identification.

14 Presentation of the sounds

Next, the participants were invited to listen through loudspeakers to the audiofiles of 5 common lung sounds stored in a computer placed in a silent room. The
sound files were taken from a set of processed files in the Movie.mp4 format,
which were deemed to be clean and devoid of artifacts, as required for an article
published previously [2]. The following sounds were presented, in that order: 1.
Normal breath sound; 2. Wheezes; 3. Crackles; 4. Stridor and 5. Pleural Friction
Rub.

22 Classification of the sound files

The observers were asked to classify the sounds successively in English and Hebrew in the order they were played (i.e. 1-5). No pre-established list of sound

nomenclature was given in either language, and the observers were asked to describe the sounds in a "free-form" format, with their own words. No sonograms, waveform analysis or clinical information were provided to substantiate the nature of the sounds. To attempt to compensate for the lack of clinical context, the observers were informed that all recordings started at the onset of inspiration. Additionally, the site of recording of each sound was indicated on a diagram, as follows: 1. Normal breath sound: posterior left basal lung region at a point situated in the scapular line, 3 cm below the angle of scapula; 2. Wheezes: anterior right upper lung zone at the intersection of the mid-clavicular line and the 2nd intercostal space; 3. Inspiratory crackles: right posterior basal region at the intersection of the scapular line and a point situated 3 cm below the angle of scapula; 4. Stridor: over the trachea, 2 cm above the supra-sternal notch; and 5. Pleural friction rub: left axillary region at the intersection of the mid-axillary line and the 5th intercostal space.

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15 Correct versus Incorrect Sound Classification

The ability to correctly identify the sounds was determined for each sound file by comparing the observers' response with the true classification i.e. clinical classification validated by computer analysis [2]. In this process, an expert selected a segment of the recorded normal sounds that was free of artifacts. A rating was considered correct if a recommended term or an accepted synonym was used to describe the sound (term use ascribed to preference). The use of any incorrect term was ascribed to lack of skills on chest auscultation.

23 Language and Auscultation Skills

The ability to correctly classify the sounds depends both on language skills and auscultation skills. For each observer, we crossed the sound classification in

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Hebrew with the corresponding classification English, performed previously by the same observers [11]. Four classes of combined skills were identified, as follows: 1. Dual-language skills and good auscultation skills. Use of accepted terms in the two languages to correctly classify a sound (e.g. use of the English term "wheeze" and the Hebrew term "tziftzufim" to classify the wheezes of sound sample # 2). 2. Dual-language skills and poor auscultation skills. Use of accepted, corresponding terms in the two languages to *incorrectly* classify a sound (e.g. use of the English term "pleural friction rub" and its *corresponding* Hebrew equivalent "shifshuf pleurali" to wrongly classify the wheezes of sound sample # 2). 3. Single-language skills and good auscultation skills. Use of a correct term in one language and an *incorrect* (or no) term in the other language to correctly classify a sound (e.g. use of the English term wheeze coupled with, say, the *incorrect* Hebrew term "hirhurim" to classify the wheezes of sound sample # 2}. 4. Poor language skills and poor auscultation skills. Use of different, incorrect terms in the two languages to classify a sound (e.g. use of "crackle" and "shifshuf pleurali" to classify the wheezes of sound sample # 2).

17 Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting ordissemination of this study.

20 Data Analysis

Baseline characteristics are presented as mean (SD) and proportions. For each
audio sample, the difference in the proportion of correct vs. incorrect rating was
tested using the Chi square test; a p < 0.05 was considered significant.

yrs. (3.5), nore than 47 (100%)
ion were: n=2, and ersions of rtition by Medicine, ogy, n=1; nd Family Hebrew,
erms used esponding ntification he stridor SP=58.6%; (SP=20%;

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3 4	1	RESULTS
5 6 7	2	Characteristics of participants
, 8 9	3	Participants' mean (SD) age was as follows: SP= 48.4 yrs. (10.4); R=32.5 yrs.
10 11	4	and MS=28.4 yrs. (4.5). Overall, 17 (54.8%) staff physicians declared more
12 13	5	20-year experience with auscultation; in turn, 60 (92%) residents and 47 (1
14 15	6	medical students declared < 5-year experience.
16 17 18	7	Language profile and specialty of staff physicians
19 20 21	8	The first language of 27 SPs who provided responses to this question
21 22 23	9	Hebrew, n=16, English, n=4, Arabic, n=2, French, n=2, Russian, n=2,
23 24 25	10	Portuguese, n=1. All respondents reported the learning of unspecified version
26 27	11	the lung sound terminology in English and Hebrew (n=23). The repartition
28 29	12	specialty was as follows: Pulmonology, n=7; Pediatrics, n=6; Internal Med
30 31	13	n=4; Cardiology, n=2; Oncology, n=2; Geriatrics, n=1; Hematology,
32 33	14	Emergency medicine, n=1; Rheumatology, n=1; Palliative care, n=1 and F
34 35	15	medicine, n=1. Twenty four SPs practiced medicine in both English and Hel
36 37	16	while 3 practiced only in Hebrew.
38 39 40	17	Correct Hebrew Terms versus Recommended English Terminology

Table 1 lists (i) the standard and phonetic forms of the correct Hebrew te sed by the three groups; (ii) their meaning in English; and (iii) the corre ling recommended English terminology. Overall, the rates of correct ider ion were high for the wheeze (SP=80%; R=79.7%; MS=87.2%; [p=.944]) and t dor (SP=96.3%; R=90.2%; MS=67.4%; [p=.544]), fair for the crackles (S 6%; R=67.2%; MS=69.8%; [p=.899]) and low for the normal lung sound 0%;

1	R=11.3%; MS=15.5%; [p=.624]) and the pleural friction rub (SP=28.6%; R=3.6%;
2	MS=2.7% [p=.002]).
3	Preference versus Poor Auscultation Skill
4	Altogether, the observers used 60 Hebrew terms to classify the 5 sounds; of these
5	11 (18.3%) were correct, being therefore ascribed to preferences regarding
6	terminology, while 49 (81.7%) were incorrect, being ascribed to lack of chest
7	auscultation skills.
8	Correct terms by group
9	Sample sound #1 (Normal breath sound): Of 137 participants classifying this file,
10	20 correctly classified it as normal. Of 3 Hebrew terms used, only 1 corresponded
11	to the recommended English term "normal breath sound".
12	Sample sound # 2 (Wheezes): Of 141 participants classifying this file, 116 (82.3%)
13	used a single Hebrew term - "Tziftzufim" - corresponding to the recommended
14	English term "Wheeze".
15	Sample sound # 3 (Crackles): Of 130 participants classifying this file, 86 (66.2%)
16	used 4 Hebrew terms to correctly classify it as crackles. However, only 1 term –
17	"Pitzputzim" - corresponded to the recommended English term crackle.
18	Sample sound # 4 (Stridor): Of 131 participants classifying this sound, 110 (84%)
19	correctly classified it by means of a Hebrew transliteration of the recommended
20	English term "stridor".
21	Sample sound # 5 (Pleural friction rub): Of 121 participants classifying this sample,
22	11 (9.1%) correctly classified it as pleural friction rub. They used 2 terms, of which
23	"Shifshuf Pleurali", meaning "Pleural rubbing", was used on 10 occasions.
24	Incorrect Hebrew Terms
	9

The 49 incorrect Hebrew terms are listed in the **e-Table 1**. Of these, 10 were used to classify the normal breath sound, 11 to classify the wheezes, 10 to classify the crackles, 8 to classify the stridor, and 10 to classify the pleural friction rub.

4 Transfer to Hebrew of the English Terminology

Identification of 5 sounds by 143 subjects would have resulted in 715 instances of identification. However, on 28 occasions the observers declined to classify a sound in either language, thus giving a total of 687 (96%) instances of sound identification. On 597 (87%) of these occasions, the observers provided terms in the two languages for all sounds, while on 90 (12.9%) they provided terms in one language only. The combination of language skills and auscultation skills, obtained by crossing the correct and incorrect responses in the 687 sessions, is given in detail in Table 2. The resulting combination of language skills and auscultation skills was a follows:

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14 1. Dual-language skills *and* good auscultation skills. n=321 (46.7%)

15 2. Dual-language skills *and* poor auscultation skills n=265 (38.6%).

3. Single-language skills and good auscultation skills. n=41 (6.0%)

4. Poor language skills and poor auscultation skills. n=60 (8.7%)

DISCUSSION

In his original work, Laennec used the terms "rale" and "rhonchus" interchangeably, to denote all classes of adventitious sounds [1]. Successive translations — first into English, then into other languages — and redefinitions of the original terminology gave different meanings to these terms, starting a confusion that persists to this day. To overcome this drawback, recommendations for use of a standardised terminology in the English language were made by the Ad Hoc committees of scientific societies [3-5]. The recommended terms -simple and precise — are based on the physics of the sounds, without assumptions about their mechanism of generation or site of production [3-5]. In a population of caregivers working in Israel, we compared the Hebrew terms used to classify 5 common sounds with: (a) the recommended terminology in English and; (b) the terms used by the same caregivers to classify the same sounds in the English language.

In similarity with our companion study [11] the observers' ability to classify the sounds in Hebrew was high for the wheezes and the stridor, fair for the crackles, and low for the normal breath sounds and the pleural friction rub, with the three groups of caregivers performing similarly in classifying all sounds. Even though the staff physicians performed better than the other groups in classifying the pleural friction rub, the overall performance of the three groups was too low to be considered clinically meaningful. This similarity of performance regarding the two languages is interesting, because, in theory, one could expect the caregivers to perform better in their working language - Hebrew - than in English.

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Of 3 correct Hebrew terms used to classify sound file # 1, just one corresponded to the recommended term "Normal breath sound" in English. The other two, "Vesiculari" and "Buyit" — meaning respectively "Vesicular" and "Alveolar" — are deemed inappropriate as they convey the incorrect assumption that the normal sound originates from the *entrance of air into and out of the air-cells of the lungs* [1]. As a quick aside, although the *exact* locale and mode of production of the normal breath sound has not been established, there is evidence to support the view that it has a double origin: the lobar and segmental airways for the inspiratory component, and a more central source for the expiratory component [12, 13]

Consistent with our previous study [11] all observers used the classic Hebrew term "Tziftzufim" to classify the wheezes. This homogeneous description is interesting. Indeed, the term "Wheezing" has been in use long before Laennec's invention of the stethoscope, while "Wheeze", as used nowadays, corresponds to the "Rale sibilant sec" described by Laennec [14]. We speculate that the traditional attribution of this sound to a single mechanism – airway obstruction – might have contributed for the use of a single term to describe it. Consequently, the translation from the source language (i.e. English) to other languages was kept relatively uniform, as found in the present study.

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The term "Stridor" — from the Latin *stridere* (harsh, shrill or creaking noise) —
describes the high-pitched, musical sound produced by turbulent flow passing
through a narrowed segment of the upper respiratory tract [15]. In similarity with
the classification of the wheezes, all correct raters used a single term. However,
instead of the Hebrew term "שׁרְמָוּק" ("Shirnuk") they used the term "Stridor" itself,
spelled in the Hebrew alphabet. This peculiar choice suggests that, rather than

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searching for a suitable terminology, the caregivers preferred a term familiar to
them. This finding is similar to that reported in a recent survey of lung sound
nomenclature carried out in 34 European countries, which showed that caregivers
from *all* the countries - representing 29 languages of which 5 had non-Latin
alphabets – spelled the term "Stridor" verbatim in all languages but Greek [16].

With two categories – "Fine" and "Coarse" – crackles can be defined as brief, non-musical, explosive, adventitious sounds [17, 18]. In this study, the Hebrew equivalent of "Crackles" was used just once, by a medical student. Of the other acceptable terms, "Crepitatziot" is solely an adaptation of "Crepitations", while "Hirhurim" is the classical Hebrew term for "Rales". It should be noted that both these terms are considered superfluous or inadequate: "Crepitations" because it merely means high-pitched crackling, and "Rales" because, as stated above, it was originally a generic term applied to every variety of adventitious pulmonary sound [1]. Incidentally, the accepted mechanism of production of fine crackles is not the presence of secretions in the airways, but the sudden opening of airways in deflated territories of the lung as observed in restrictive lung disorders (e.g. Interstitial Lung Disease) [17-19].

Of the presented sounds, the pleural friction rub is probably the less well-studied. Purportedly, it is produced by the sudden release of tangential tension in a superficial portion of the lung momentarily arrested in its sliding movement by a frictional force between the two pleurae [**18**]. The tiny group of observers who correctly classified this sound used 2 terms (vs. 4 terms in the English part of the survey [**11**]): pleural and friction, alone or in combination. Page 15 of 22

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A novel information provided by this study is that poor skills in chest auscultation largely surpassed deficient language skills as a cause of incorrect lung sound classification. Of 90% of participants found to have good language skills, 50% had poor auscultation skills. Consistent with our previous study [11] this finding further illustrates the fact that the use of recommended terminology is meaningful only among observers with good auscultation skills. In fact, observer agreement on a wrong classification can be detrimental to the patients, as it may lead to unnecessary and expensive investigations as well as improper treatment [11].

Most of our staff physicians practiced medicine in both Hebrew and English. This aspect has clinical relevance. The ability of nonnative English-speaking doctors to communicate with patients in English is now considered a core-competency. Consistent with its status of global lingua franca, the English language is the universal means of communication between people with different native languages. In this context, ensuring the similarity of terminology between English and a LOTE is important, as language-concordant health care contributes to prevent expensive tests and poor patient follow-up.

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To our knowledge, there is no research similar to this study that can provide data for comparison. Searching the literature, we found that the importance of the correct understanding of the original English terminology by caregivers working in a LOTE has been examined only peripherally. For instance, in a survey of seven European countries, lack of familiarity with the English nomenclature was invoked to explain the lower agreement of Russian and Dutch practitioners to classify crackles and wheezes from video-recordings [20]. Also, in the European terminology survey quoted above, the terms used across the countries were

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generally non-uniform, some countries having their own terminology, others
simply adopting the English terminology [16].

This study has limitations. First, for the sake of feasibility, we recruited caregivers from the same hospital, which may limit the generalisability of the findings. However, compensation was provided by their heterogeneity in terms of clinical and educational background. Second, we did not investigate all adventitious sounds. For simplicity, we stuck to the commonest ones, intentionally excluding more complex sounds such as, for instance, the rhonchus or the squawk, whose inclusion might have further hampered the observers' ability to classify the sounds. Finally, the experimental conditions were not representative of those in clinical practice. The study design prevented the participants to auscultate all over the chest, at will, or to command the respiratory maneuvers, which may have altered outcomes compared with real-life. However, to avoid more detrimental biases we were forced to standardize the study conditions across participants.

15 CONCLUSION

In this study, the Hebrew terms used to classify common lung sounds corresponded only partly to the recommended terminology. Many Hebrew terms were adaptations or transliterations of inappropriate English terms (e.g. "Vesicular sound", "Crepitations"). Noticeably, a high proportion of matched Hebrew/English terms was incorrect. These data support the conclusion that poor auscultation skills surpassed poor language skills as a factor hampering the meaningful transfer of the recommended terminology to a LOTE (Hebrew). In this context, improved education in chest auscultation should be the main prerequisite for the successful dissemination of the recommended terminology.

Based on our results, some suggestions can be made to encourage the widespread use of a standardised lung sound terminology in non-native English speaking countries. Countries with a high knowledge of English could simply adopt the recommended English terminology verbatim. Alternatively, countries with a lower knowledge of English could opt for the translation of the recommended terms by professionals skilled in both the source (English) and the target (LOTE) language. Finally, if resources for translation are not available, transliteration of the recommended terms seems a viable option. Adopted spontaneously by many observers in this study, transliteration requires no special language skills and can be performed in any language, including those with non-Latin alphabets. For its simplicity, it should be given consideration by the medical societies of all concerned countries.

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29 30		
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34 35		
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39 40		
40 41		
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43		
44 45		
4.)		

Table	1. Compari	ison O	f Hebrew	Terms	With	Recomme	nded Er	nglish T	erms	Used
By Thr	ee Groups	of Care	egivers to	Classify	/ Five	Lung Soun	ds			
										-

Audio	Recommended Terminology		Hebrew Terms		Fr	equency of Use
sample	in the English Language	Standard	Phonetic	English Meaning	n	By Group
#1	Normal breath sound	נשימה נורמלית	Neshima			
			normalit	Normal breathing	8	SP=1 R= 3; MS=4
		נשימה וסקולרית	Neshima	Vesicular		
			vesicularit	breathing ³	2	SP=2
		נשימה בועית	Neshima buit	"Alveolar"		
				breathing ³	10	SP=3 R= 4; MS=3
# 2	Wheezes	צפצופים	Tziftzufim	Wheezes		SP=24 R=51
					116	MS=41
#3	Crackles	קריפיטציות	Crepitatziot			SP=12 R=17
				Crepitations ³	42	MS=13
		פיצפוצים	Pitzputzim	Crackles	1	MS=1
		פקעיים	Pkaim	Fine Crepitations ³	1	MS=1
		חרחורים				SP=5 R=22
			Hirhurim	Rales	42	MS=15
#4	Stridor ¹	² סטרידור		Stridor		SP=26 R=55
			Stridor		110	MS=29
# 5	Pleural friction rub ¹	שפשוף פלאורלי	Shifshuf pleurali	Pleural rubbing ³	10	SP=8 R=1 MS=1
		פריקשן	Friction	Friction	1	R=1

1. Term suggested [ref # 2]

3/2 2. The correct term - שָׁרְנוּק (shirnuk) - was not used by any rater.

3. Term considered correct but nor recommended

SP= Staff physicians; R= Residents; MS= Medical students

BMJ Open BMJ Open Table 2: Language and Auscultation Skills Among Staff Physicians, Residents and Medical Students: English versus Terminology in LOTE

		Possible	Number of Se	essions of Sour	nd Identificatio	on for All Obs	ervers (n=	9 715)	
	Obson	rs providing (2 2					
	Observers providing classification in the two languages (n=597)				Observe				
	Similar terms		· /	erms in the	English	language or (n=27)		<u>- N</u> ev¥(n=63)	No
	languages	(n=586)	two langua	ages (n=11)					classification
	Both terms	Both terms	English	Hebrew				wnle	in either
Sound	correct ¹	Incorrect ²	correct ³	correct ³	Correct ³	Incorrect ⁴	Correct ³	alncorrect ⁴	language
Classification	(n=321)	(n=265)	(n=7)	(n=4)	(n=14)	(n=13)	(n=16)	<u> </u>	(n=28)
# 1 Normal	19 (5.9%)	106 (40.0%)	1	0	0	3	1	from h 10	3
								.tp://t	
# 2 Wheeze	110 (34.3%)	19 (7.2%)	2	1	2	0	5	//bmjop	0
								ben.	
# 3 Crackle	77 (24.0%)	34 (12.8%)	2	3	4	2	6	n.bmj.com	7
		31(1210/0)	_			_			
# 4 Stridor	104 (32.4%)	17 (6.4%)	2	0	5	3	4		4
	104 (32.4%)	17 (0.470)	2	0	5	5	4	on April	4
								119	
# 5 PFR	11 (3.4%)	89 (33.6%)	0	0	3	5	0	8 21	14
	ge skills <i>and</i> good		•	•				24 b	
	ge skills <i>and</i> poor		•	•				א פר	
	age skills and goo							lest	
4. Poor languag	e skills <i>and</i> poor	auscultation s	kills. n=60 (8.	7%)				Pro	
								otect	
								ted t	
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								opyr	
				21				20 21 20 24 by guest. Protected by copyright.	

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Sound	- · · · · ·				
Sample	Standard Hebrew	Phonetic Hebrew	English Meaning	n	Repartition by grou
#1 NBS	קריפיטציות	Crepitatziot	Crepitations	60	SP=10 R=37 MS=13
N=10	חרחורים	Hirhurim	Rales	32	SP=3 R=11 MS=18
	נשימה ברונכיאלית	Neshima bron <u>ch</u> ialit	Bronchial breathing	18	SP=8 R=6 MS=4
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	MS=1
	ירידה עם חירחורים עדינים	Yerida im hirhurim adinim	Diminished with fine rales	1	MS=1
	שפשוף	Shifshuf	Friction	1	SP=1
	ציפצופים	Tziftzufim	Wheezes	1	MS=1
	שיפשוף פליאורלי	Shifshuf pleurali	Pleural friction	1	SP=1
	פיכפוך	Pichpuch	Bubbling	1	R=1
	רישרוש של פלוירה	Rishrush shel pleura	Pleural friction	1	SP=1
#2 Wheeze	סטרידור	Stridor	Stridor	4	SP=1 R=2 MS=1
N=11	חרחורים	Hirhurim	Rales	1	MS=1
	קרפיטציות	Crepitatziot	Crepitations	1	MS=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	SP=1 R=1
	חיכוך פליאורלי	Chikuch pleurali	Pleural friction	1	SP=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	8	SP=2 R=5 MS=1
	גניחות	Genihot	Groan	1	R=1
	אנחות	Anahot	Sigh	1	SP=1
	אוושה סיסטולית	Ivsha sistolit	Systolic murmur	4	R=3 MS=1
	מיוזיקלי	Musicali	Musical	1	R=1
	קולות ממקור עליון	Kolot mimakor elion	Sounds from upper source	1	MS=1
#3 Crackle	נשימה ברונכיאלית/תקינה	Neshima bronchialit tekina	Normal bronchial br.	19	SP=7 R=10 MS=2
N=10	נורמלי	Normali	Normal	6	SP=1 R=2 MS=3
	נחירות	Nehirot	Snoring	1	SP=1
	כניסת אוויר מופחתת	Knissat avir mufhetet	Diminished air entry	1	MS=1
	כניסת אוויר מופחתת,רשרו	Knissat avir mufhetet im	Diminished air entry with	1	MS=1
	אקספירטורי	rishrush expiratoy	expiratory rustle		
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	2	R=1 MS=1
	ציפצופים	Tziftzufim	Wheezes	2	R=1 MS=1
	נשימה בועית	Neshima buyit	Vesicular breathing	9	SP=3 R=3 MS=3
	כניסת אוויר ירודה	Knisat avir yeruda	Decrease air entry	2	R=1 MS=1
	אקספיריום מאורך	Expirium meorah	Prolonged expiration	1	R=1
#4 Stridor	ציפצופים	Tziftzufim	Wheezes	14	SP=1 R=5 MS=8
N=8	וויזינג	Wizing	Wheezing	1	MS=1
	השתנקות	Histankut	Gasping	1	MS=1
	שריקה	Shirika	Whistle/wheezing	1	MS=1
	דיבור	Dibur	Talk	1	MS=1
	ברונכוספאזם	Bronchospasm	Bronchospasm	1	MS=1
	מיוזיקל	Musical	Musical	1	R=1
	חריקה/שרנוק	Harika	Creak/Friction	1	MS=1
#5 PFR	ריילס	Rales	Rales	1	SP=1
N=10	קריפיטציות	Crepitatziot	Crepitations	13	SP=4 R=5 MS=4
	חרחורים	Hirhurim	Rales	78	SP=15 R=36 MS=27
	ירידה בכניסת אוויר	Yerida beknissat avir	Decrease air entry	1	MS=1
	ציפצופים	Tziftzufim	Wheezes	1	R=1
	נשימה ברונכיאלית	Neshima bronchialit	Bronchial breathing	12	R=9 MS=3
	נשימוז בו ונכיאליונ שיפשוף פריקרדיאלי	Shifshuf pericardiali	Pericardial friction rub	12	MS=1
	· · ·				
	פיכפוך איווואה	Pichpuch	Bubbling	1	R=1
	איוושה גודש בועמי	Ivsha Cadaab raiati	Murmur	1	R=1
	גודש ריאתי	Godesh reiati	Pulmonary congestion	1	R=1

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students