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Laboratory Validation of Sound Level Meter Mobile Applications with Reference Sound Level Meter

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Abstract: ***National Institute for Occupational Safety and Health (NIOSH) estimates that more than 22 million people in the United States are exposed to noise levels in excess of 85 A-weighted decibels (dBA) at their place of work. The World Health Organization (WHO) estimates that more than 5% of the work population (360 million people) have disabling hearing loss (WHO, 2012). Occupational noise-induced hearing loss is preventable. However, once acquired, it is permanent and irreversible (NIOSH, 1998). Advanced technology in the form smart phones have made everything accessible to its end users in the form of mobile application (apps). The smart phones work under two predominant platforms worldwide such as ANDROID and IOS. The sound level meter apps are available online for free. These apps can used to measure the noise level in the community and work place. This would help the public to identify noise levels by downloading free noise apps and be aware of the noise levels and take actions to conduct a comprehensive noise assessment and assess the need for reducing noise exposures and protect them from noise induced hearing loss and other non-auditory effects.***

Keywords: Community noise, Mobile applications, Noise levels, Sound level meter.

1. Introduction

Noise pollution is an undesirable and one of the common environmental exposures which are not only disruptive but also dangerous to life, nature, and property. According to studies, Community and Industrial noises are the two major noises that result in partial or permanent injuries to human ears. The community noise includes noises emitted from road traffic, loud speaks, automobiles, industries, constructional activities, fireworks, railways, air crafts etc. and the domestic noise sources like refrigerator, juicer-mixer-grinder, television, washing machine, etc. Most of the auditory and non-auditory health problems are the consequences of exposure to these noises beyond the permissible limits. Auditory fatigue and noise induced hearing loss are being the direct outcome of the auditory health effects while physical disorder like annoyance, sleep disturbance, cardiovascular disease and impairment of cognitive performance in children are the indirect outcome of non-auditory health effects.

National Institute for Occupational Safety and Health (NIOSH) estimates that more than 22 million people in the United States are exposed to noise levels in excess of 85 A-weighted decibels (dBA) at their place of work. The World Health Organization (WHO) estimates that more than 5% of the work population (360 million people) have disabling hearing loss (WHO, 2012). Occupational noise-induced hearing loss is preventable. However, once acquired, it is permanent and irreversible (NIOSH, 1998).

In order to overcome this hazardous exposure, it is important to recognize that noise is a hazard, know their present level of exposure and understand if they are exposed to safe levels. A sound level monitor or noise dosimeter is required to measure the environmental noise or exposure level. Although there are various equipment available to measure noise, the availability, access and the cost of the equipment like Sound Level Meter (SLM), Noise Dosimeter are expensive and may not be affordable, therefore restricting the use of these equipment even if there are requirements for monitoring.. Further, this equipment requires professional expertise to operate and to gather information for detailed noise measurements.

Advanced technology in the form smart phones have made everything accessible to its end users in the form of mobile application (apps).The smart phones works under two predominant platforms worldwide such as ANDROID and IOS. The sound level meter apps are available online for free. These apps can be used to measure the noise level in the community and work place. This would help the key professionals like Audiologists, Industrial Hygienist, Academicians and Research scholars and general public to identify the noise levels by downloading free noise apps and be aware of the noise levels and take actions to conduct a comprehensive noise assessment and assess the need for reducing noise exposures and protect them from noise induced hearing loss and other non-auditory effects. One limitation of these apps are; it could not be used for measuring noise for legal compliance and neither the hand phone devices nor the application are meeting the ANSI specification for monitoring noise levels. However, these could be used as a screening tool to map the high and low noise areas for surveillance purpose. Modernization in mobile technology has made use of many free apps and feasible to use ―SLM APPS‖ for screening noise levels at workplace. These most commonly used SLM apps are readily available in play store & app store, low MB space, free of cost, feasible to use and can be used quickly. The American National Standards Institute (ANSI) explicitly defines SLM performance and accuracy tolerances. Type1 SLMs must be accurate within ±1 dB, and Type 2 SLMs must be accurate within ±2 dB. A third category, the Type 0, references high-precision instruments typically used in the laboratory rather than for field measurements.

A Type 2 SLM is typically appropriate for use in meeting occupational noise monitoring requirements set by the Occupational Safety and Health Administration (OSHA) and ideally smartphone-based apps would meet the Type 2 criteria if they are to be useful in estimating noise hazard. Reliability of the sound levels measured using these APPS are of concerns as there is low accuracy as reported in few literatures. Hence, there is a need for the study to evaluate these apps under varying test conditions.

Rationale of the study

- The SLM apps from smartphones provide reasonably reliable values with only selected type of smartphone.
- Accuracy level varies when tested between Type I and Type II SLMs.
- Sound levels measured varies by types of Applications and microphones in the smart phones
- This study is undertaken to validate those applications in laboratory under varying test conditions with respect to different smartphones, Applications, SLM, microphones, distance and noise.

Study aim and objectives

Aim

To identify the reliable sound level meter applications that can be used in smartphones to measure noise levels for screening purpose in occupational and environmental settings

Objectives:

To select applications with 4.5 star rates and test under Android and IOS platform

- To measure pure tone at various octave frequencies and Intensities
- To compare the measurements between internal microphone and external microphone
- To test the measurements by different types of noise (Continuous and Intermittent) at varying distances (2feet vs 4feet)
- To compare the measurements between Type I and Type II SLM

2. Methodology

This study design is based on **cross-sectional study,** where the samples were collected from an authentic 2 step acoustic controlled room in Chennai. The equipment implied in the study are:

- Type 1 Sound level meter - BSWA Model 308 (manufactured by BSWA, from Beijing, China).
- Type 2 Sound level meter - 3M Model SE-402 (manufactured by Cole-Parmer India Pvt.Ltd fromMumbai, India).
- Pure tone audiometer – Piano inventis basic model audiometer (manufactured by inventis audiology equipment from Padova, Italy).
- External microphone - BOYA Model BY-MM1 (manufactured by Shenzhen Jiayz industrial, Ltdfrom China).

Applications: Mentioned in table 1 along with version and star ratings.

Table 1: Applications chosen under each platform

ANDROID	RATINGS	VERSION	IOS	RATINGS	VERSION
Bosch INVH	5	2.1.1	dB meter	5	6.2
Sound meter HD	4.5	2.0.2	NIOSH SLM	5	1.2.1
Sound meter	4.5	2.1	Decibel	4.5	1.6.11
Sound detector	5	1.2.1	Sound level	5	2.0.2
Sound meter	4.5	4.0.1	Decibel X	4.5	8.2.1

5 readings were taken from each application at each frequency & intensity of each parameter, inclusion Criteria was considered as >4.5 rated applications, android and IOS (platform) mobile phones Exclusion Criteria was Microsoft platform (windows). The collected data will be entered in Microsoft Excel and statistical analysis willbe performed using SPSS software.

Schematic of Laboratory Testing

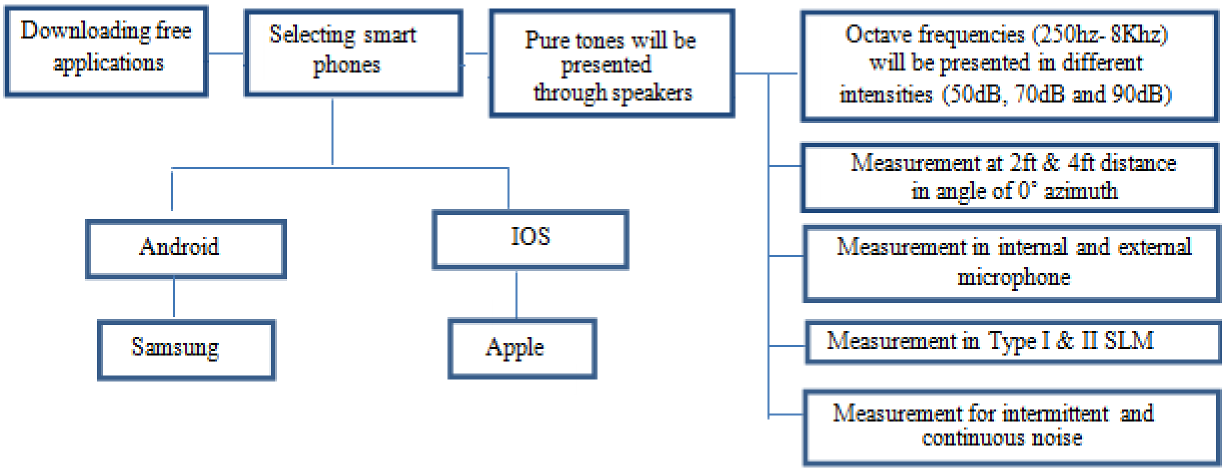

Figure 1: Schematic of Laboratory testing

A basic type 1 sound level meter BSWA Model 308 & type 2 sound level meter - 3M Model SE-402 was used for the study. Android and IOS platforms has unique sets of applications, were android apps cannot be seen in IOS platform (respective to SLM applications), hence 5 different applications were chosen from each platform. According to the star ratings and positive reviews five free >4.5 star rated ―Android apps‖ from Play store & IOS apps from ―App store‖ were chosen under each platform as mentioned in the table 1. Qure speech and hearing clinic at vadapazhani, Chennai was chosen for the study. The clinic is situated in hot of city having infrastructures with two setup acoustic controlled room. ‗PIANO' Inventis, a basic model audiometer was used to present the pure tone of 50, 70 & 90 dBHL (pink noise). The sound level meter apps in different smart phones was kept parallel at distance of 2 & 4 feet in the angle of 0˚azimuth and two types of pure tone stimulus was presented through free field speakers (FBT 5A processed active monitor) such as intermittent and continuous tone. The SLM I & II were pre-calibrated. The frequency (250HZ, 500HZ, 1K, 2K, 4K, 8K) was measured

in specific apps in 2 different mobile phones (Samsung galaxy S6 & apple 6S) from 2 different operating systems (android & IOS).The tone was measured for 2 minutes at the distance of 2 feet & 4 feet from the source and the measurements were taken in both internal & external microphone BOYA BY-MM1 using the smartphones and SLM I & II simultaneously.

3. Results

Table 2: Comparison of noise levels between Type 1 sound level meter and various applications tested at various distance and sound levels using Internal android microphone and External microphone

S. No	*Application*	*Type of noise and distance*	*Distance of measurement (feet)*	*50 dB – R^2 values*		*70 dB – R^2 values*		*90 dB – R^2 values*	
				Internal microphone	External microphone	Internal microphone	External microphone	Internal microphone	External microphone
1	BOSCH INVH	Continuous	2	0.33	0.42	0.14	0.17	0.18	0.42
			4	0.35	0.22	0.31	0.17	0.09	0.19
		Intermittent	2	0.18	0.21	0.22	0.18	0.16	0.5
			4	0.22	0.44	0.29	0.13	0.3	0.4
2	SOUND METER	Continuous	2	0.27	0.14	0.09	0.22	0.19	0.22
			4	0.26	0.27	0.17	0.36	0.11	0.47
		Intermittent	2	0.33	0.25	0.17	0.32	0.2	0.13
			4	0.37	0.42	0.23	0.29	0.21	0.21
3	SOUND METER HD	Continuous	2	0.31	0.07	0.3	0.31	0.15	0.27
			4	0.33	0.5	0.42	0.25	0.12	0.11
		Intermittent	2	0.16	0.15	0.15	0.25	0.22	0.25
			4	0.39	0.34	0.23	0.32	0.23	0.37
4	SOUND DETECTOR	Continuous	2	0.1	0.22	0.3	0.06	0.17	0.08
			4	0.26	0.29	0.34	0.19	0.13	0.22
		Intermittent	2	0.2	0.35	0.24	0.31	0.21	0.28
			4	0.23	0.32	0.2	0.12	0.26	0.33
5	SOUND METER DB	Continuous	2	0.38	0.29	0.17	0.21	0.14	0.39
			4	0.42	0.18	0.27	0.41	0.11	0.31
		Intermittent	2	0.28	0.37	0.29	0.19	0.2	0.35
			4	0.41	0.38	0.14	0.28	0.25	0.07

The table 2 shows goodness of fit (correlation) of android platform (Samsung Galaxy S6) applications with type 1 SLM using comparison of internal android and external microphone at distance of 2ft. and 4ft.tested with two types of noise (continuous and intermittent) at 50dB, 70dB and 90dB. The App BOSCH INVH shows medium correlation at 50dB at 2ft. continuous noise and 4ft. Intermittent noise using external microphone (r^2=0.42, r^2=0.44); in 90dB the same app shows medium correlation at 2ft. continuous noise and better correlation (r^2=0.42, r^2=0.5) at 2ft. intermittent noise using external microphone. The Sound Meter App shows medium correlation at 50dB 4ft. intermittent noise using external microphone (r^2=0.42), similarly at 90 dB the app depicts medium correlation at 4ft. continuous noise from external microphone (r^2=0.47). The app Sound Meter HD shows strong correlation at 4ft. continuous noise from external microphone (r^2=0.5), at 70dB the same app shows medium correlation at 4ft. continuous noise (r^2=0.42). The Sound Detector App ranges between medium to small correlation under all 3 decibels and lab conditions in both microphones (r^2=0.1 - r^2=0.33). The Sound Meter DB app shows medium correlation at 50dB at 4ft. continuous and intermittent noise from internal microphone (r^2=0.42, r^2=0.41); in 70dB the same app shows medium correlation at 2ft. continuous noise from external microphone.

Table 3: Comparison of noise levels between Type 2 sound level meter and various applications tested at various distance and sound levels using internal android microphone and External microphone

S. No	*Application*	*Type of noise and distance*	*Distance of measurement (feet)*	*50 dB - R2 values*		*70 dB - R2 values*		*90 dB - R2 values*	
				Internal microphone	External microphone	Internal microphone	External microphone	Internal microphone	External microphone
1	BOSCH INVH	Continuous	2	0.46	0.45	0.42	0.63	0.25	0.26
			4	0.17	0.27	0.47	0.08	0.16	0.23
		Intermittent	2	0.38	0.22	0.32	0.12	0.49	0.15
			4	0.33	0.18	0.26	0.12	0.25	0.33
2	SOUND METER	Continuous	2	0.3	0.19	0.26	0.19	0.28	0.34
			4	0.14	0.27	0.28	0.41	0.37	0.2
		Intermittent	2	0.52	0.25	0.2	0.19	0.69	0.23
			4	0.11	0.27	0.23	0.36	0.47	0.53
3	SOUND METER HD	Continuous	2	0.26	0.07	0.3	0.47	0.25	0.44
			4	0.23	0.29	0.46	0.24	0.26	0.31
		Intermittent	2	0.37	0.48	0.38	0.31	0.45	0.36
			4	0.36	0.21	0.48	0.3	0.07	0.26
4	SOUND DETECTOR	Continuous	2	0.21	0.33	0.47	0.37	0.25	0.23
			4	0.26	0.18	0.24	0.36	0.36	0.26
		Intermittent	2	0.19	0.33	0.43	0.38	0.54	0.18
			4	0.42	0.35	0.34	0.17	0.28	0.13
5	SOUND METER DB	Continuous	2	0.31	0.12	0.34	0.23	0.34	0.25
			4	0.31	0.26	0.3	0.64	0.15	0.19
		Intermittent	2	0.44	0.24	0.26	0.18	0.36	0.49
			4	0.18	0.21	0.44	0.61	0.28	0.16

The table 3 shows goodness of fit (correlation) of android platform (Samsung Galaxy S6) applications with type 2 SLM using comparison of internal android and external microphone at distance of 2ft. and 4ft.tested with two types of noise (continuous and intermittent) at 50dB, 70dB and 90dB. The App BOSCH INVH shows medium correlation at 50dB at 2ft. continuous noise (r^2=0.46, r^2=0.45) in both microphones; at 70dB the app shows medium correction at 2ft. & 4ft. continuous noise from internal microphone(r^2=0.42, r^2=0.47); strong correlation in 2ft. continuous noise from external microphone (r^2=0.63). In 90dB the app depicts almost strong correlation in 2ft. intermittent noise from external noise (r^2=0.49). The App Sound Meter shows strong correlation in 2ft continuous noise (r^2=0.52); in 70dB the app shows medium correction at 4ft. continuous noise from internal microphone (r^2=0.41);in 90dB the app shows strong correlation in 2ft. intermittent noise from internal microphone (r^2=0.69) and medium correlation in 4ft. intermittent noise from internal microphone (r^2=0.47); in 90dB app shows strong correlation in 4ft. intermittent noise from external microphone (r^2=0.53). The App Sound Meter HD shows medium correlation in 50dB at 2ft. intermittent noise in external microphone (r^2=0.48); in 70dB the app shows medium correlation in 4ft. continuous and intermittent noise from internal microphone (r^2=0.46, r^2=0.48); in 90dB the app shows medium correlation at 4ft. intermittent from internal microphone (r^2=0.45) & at 2ft. continuous noise from external microphone (r^2=0.44). The App Sound Detector shows medium correlation at 4ft.intermittent noise from internal microphone (r^2=0.42); in 70dB the app depicts again medium correlation at 2ft. continuous and intermittent noise from internal microphone (r^2=0.47, r^2=0.43); in 90dB the app shows strong correlation at 2ft. intermittent from internal microphone (r^2=0.54). The App Sound Meter DB shows medium correlation at 2ft. intermittent noise from internal microphone (r^2=0.44); in 70dB the app shows medium correlation at 4ft intermittent noise from internal microphone (r^2=0.44); & the app shows strong correlation at 4ft. continuous and intermittent noise in external microphone (r^2=0.64, r^2=0.61); In 90dB the app depicts almost strong correlation in 2ft. intermittent noise from external noise (r^2=0.49).

Table 4: Comparison of noise levels between Type 1 sound level meter and various applications tested at various distance and sound levels using Internal IOS microphone and External microphone

S. No	*Application*	*Type of noise and distance*	*Distance of measure ment (feet)*	*50 dB - R^2 values*		*70 dB - R^2 values*		*90 dB - R^2 values*	
				Internal microp hone	External microp hoe	Internal microp hone	External microph one	Internal microp hone	External microph one
1	DB METER	Continuous	2	0.3	0.31	0.18	0.07	0.16	0.17
			4	0.25	0.09	0.38	0.32	0.26	0.21
		Intermittent	2	0.25	0.35	0.21	0.37	0.25	0.16
			4	0.22	0.25	0.24	0.1	0.2	0.16
2	NIOSH SLM	Continuous	2	0.3	0.26	0.09	0.02	0.14	0.19
			4	0.42	0.18	0.34	0.32	0.16	0.29
		Intermittent	2	0.28	0.42	0.19	0.11	0.15	0.41
			4	0.18	0.22	0.16	0.17	0.22	0.29
3	DECIBEL	Continuous	2	0.39	0.12	0.25	0.14	0.17	0.28
			4	0.2	0.35	0.2	0.23	0.49	0.46
		Intermittent	2	0.26	0.29	0.08	0.31	0.3	0.26
			4	0.32	0.5	0.2	0.25	0.15	0.29
4	SOUND LEVEL	Continuous	2	0.45	0.15	0.17	0.23	0.36	0.47
			4	0.23	0.44	0.2	0.46	0.37	0.17
		Intermittent	2	0.09	0.34	0.2	0.25	0.33	0.15
			4	0.3	0.2	0.32	0.37	0.11	0.37
5	DECIBEL X	Continuous	2	0.19	0.1	0.2	0.26	0.27	0.27
			4	0.28	0.12	0.35	0.18	0.21	0.21
		Intermittent	2	0.17	0.31	0.26	0.28	0.17	0.14
			4	0.22	0.17	0.23	0.04	0.4	0.45

The table 4 shows goodness of fit (correlation) of IOS platform (Apple 6S) applications with type 1 SLM using comparison of internal IOS and external microphone at distance of 2ft. and 4ft. tested with two types of noise (continuous and intermittent) at 50dB, 70dB and 90dB. The App DB meter ranges between medium to small correlation under all 3 decibels and lab conditions in both microphones (r^2=0.07 r^2=0.38). In 50dB App NIOSH shows medium correlation at 4ft. continuous noise measured from internal microphone and same app in 90dB depicts medium correlation at 2ft. intermittent noise from external microphone (r^2=0.41). The Decibel shows almost strong correlation in 90dB at 4ft. continuous from internal microphone (r^2=0.49). The App Sound level shows medium correlation at 50dB at 2ft. continuous noise from internal microphone (r^2=0.45). The App Decibel X shows medium correlation in 90dB at 4ft. intermittent noise in both microphone (r^2=0.4 r^2=0.45)

Table 5: Comparison of noise levels between Type 2 sound level meter and various applications tested at various distance and sound levels using Internal IOS microphone and External microphone

S. No	*Application*	*Type of noise and distance*	*Distance of measure ment (feet)*	*50 dB - R^2 values*		*70 dB – R^2 values*		*90 dB – R^2 values*	
				Internal microp hone	External microp hoe	Internal microp hone	External microph one	Internal microp hone	External microph one
1	DB METER	Continuous	2	0.22	0.09	0.09	0.27	0.15	0.25
			4	0.17	0.16	0.16	0.08	0.27	0.11
		Intermittent	2	0.26	0.5	0.1	0.3	0.39	0.44
			4	0.25	0.19	0.3	0.21	0.11	0.19
2	NIOSH SLM	Continuous	2	0.13	0.03	0.43	0.27	0.27	0.31
			4	0.42	0.2	0.3	0.5	0.33	0.36
		Intermittent	2	0.35	0.38	0.27	0.35	0.48	0.31
			4	2.3	0.32	0.09	0.46	0.13	0.47
3	DECIBEL	Continuous	2	0.12	0.26	0.28	0.25	0.31	0.29
			4	0.23	0.31	0.31	0.24	0.34	0.22
		Intermittent	2	0.23	0.26	0.26	0.11	0.29	0.51
			4	0.35	0.42	0.23	0.16	0.29	0.35
4	SOUND LEVEL	Continuous	2	0.39	0.26	0.17	0.24	0.41	0.5
			4	0.29	0.25	0.57	0.42	0.18	0.13
		Intermittent	2	0.4	0.16	0.33	0.37	0.28	0.52
			4	0.5	0.13	0.4	0.29	0.32	0.21
5	DECIBEL X	Continuous	2	0.18	0.28	0.33	0.24	0.48	0.34
			4	0.09	0.5	0.35	0.22	0.45	0.29
		Intermittent	2	0.38	0.2	0.2	0.24	0.37	0.17
			4	0.21	0.4	0.24	0.16	0.39	0.23

The table 5 shows goodness of fit (correlation) of IOS platform (Apple 6S) applications with type 2 SLM using comparison of internal IOS and external microphone at distance of 2ft. and 4ft. tested with two types of noise (continuous and intermittent) at 50dB, 70dB and 90dB. The App DB meter depicts strong correlation in 50dB at 2ft.

intermittent noise in external microphone (r^2=0.5), in 90 dB the same app shows medium correlation in 90dB at 2ft.intermittent in external microphone. The App NIOSH shows medium correlation in 50dB at 4ft. continuous noise and in 70dB the app again shows medium correlationat 2ft. continuous noise in internal microphone (r^2=0.42, r^2=0.43) & strong correlation at 4ft. continuous noise in external microphone (r^2=0.5). The App Decible shows strong correlation in 90dB at 2ft.intermittent noise (r^2=0.51) from external microphone. The App Sound Level shows strong correlation in 50,70 & 90dB at 4ft. Intermittent and continuous noise, measured from internal and external microphone (r^2=0.5, r^2=0.57, r^2=0.51). The App Decibel X shows strong correlation in 70dB at 4ft. continuous noise as measured in external noise (r^2=0.5)

4. Discussion

The present study tested the accuracy of 10 different SLM apps on 2 different smartphones at varying sound levels using six different sound signals. It differed from previous studies by testing a wider rangeof sound signals, different noise and microphone. The goal was to determine the relationship between the type of sound signal used and accuracy of measurement results. This allowed for a more accurate representation of the various ranges of sound expected to be present in an occupational or environmental scenario. Results showed varying degrees of performance for SLM apps.

This study has shown the accuracy of an Android (Samsung galaxy S6) and IOS (Apple 6S) in measuring noise exposure levels in selected application. This is particularly relevant to small businesses, which require noise monitoring but may not have access to a calibrated sound level meter, or to those working inremote locations. The software used was important for accuracy, highlighting the importance of selecting the correct application for optimal noise monitoring. Employees must be aware of noise present around them and able to assess noise exposure levels. However, in the absence of a traditional sound level meter, this is likely to prove challenging. Ibekwe et al. suggested that the phone apps tested produced readings within acceptable error limits for type 2 sound level meter devices. However, even such small inaccuracies can be of clinical significance; NIOSH recommended that a 3 dB increase in sound level can halve the safe listening time. The accurate and consistent readings are crucial in the assessment of noise exposure levels, especially in occupational settings where individuals can be exposed for prolonged periods of time.

This study highlights the relative accuracy of IOS platform, the Decibel app was with in r^2=0.5 which was observed in internal microphone using comparison of sound level meter I and the Decibel & Sound Meter app was observed to be r^2=0.5 in external microphone of tested levels from 90dB when compared with sound level meter type 2. For occupational noise exposure, accurately measuring high noise thresholds is arguably more important than the lower thresholds due to the limits in noise exposure levels and requirements to the employer to provide protection above 80 dB. In Android platform the Bosch INVH shows the accuracy of r^2=0.5 in internal microphone using comparison of sound level meter I at 90dB, In Sound level meter II Bosch INVH, Sound meter and Sound detector apps shows accuracy of r^2>0.5-0.7 in external microphone. This depicts external microphones picks measurements better than internal microphone for android platform, when it comes to IOS platform internal microphone picks measurements similar to external microphone were significant difference has not seen much.

In addition to this, it is observed that few studied Applications such as BOSCH INVH, SOUND METER, SOUND DETECTOR for Android and DB METER, SOUND LEVEL, DECIBEL X for IOS smartphonescan be used in occupational settings for screening purpose because measurements taken from these applications are quite reliable with type II SLM. At some places variations are seen widely that could happen due to wrong placement of microphone or body baffle effect or presence of reflective noise during the measurements. Precisions are found to be less at some conditions (distance and type of noise) in all there decibels (50,70,90dB), that could occur in case of reduced microphone sensitivity from smartphones to pick up sound signals.

5. Conclusion

This study shows that certain sound measurement apps such as BOSCH INVH, SOUND METER, SOUND DETECTOR for Android and DB METER, SOUND LEVEL, DECIBEL X for IOS smartphones and may be considered reliable for use in noise screening. From an Environmental and Occupational perspective, these apps can be useful for industrial hygienists and safety and health managers to make quick spot measurements and also serve to empower the safety managers and workers to help them recognize the noise levels and exposures in workplaces and take decision to identify the areas that needs detailed evaluation and surveillance with respect to identified work environments.

6. Limitations

Identification of platform specific app is essential for noise monitoring. Application compatibility varies from Android to IOS system; hence application familiarity is important protocol for the user. Prolonged usages of app or continuous monitoring can slowdown and hag the smartphone due to running applications for > 45mins, heat generated from phone and battery drain of the phone. The test conducted was not full proof acoustic treated room. Hence, the variations in the results could be attributed to external noise disturbances. Acoustic treated room is necessary to avoid external noise source therefore bias of app measurement can be limited. Continuous noise monitoring in greater intensity at high frequency leads to physical discomfort. And partial presence of community noise can bias the results.

7. Recommendation

In this study few apps met the mark with sound level meter I & II in two different platforms. Under Android - ***Bosch INVH, Sound meter, Sound detector*** and under IOS – ***Decibel and Sound meter apps*** gives similar values to sound level meter. In occupational setting at 90dB for continuous and intermittent noise at 2ft. distance, android smart phones with above mentioned applications can be used for screening purpose. Though apps are much feasible to measure, only gold standard instruments are always reliable, those apps can be used for screening purpose in field and work place.

References

[1] Benjamin D. Blair ● Stephen Brindley ● John Hughes ● Eero Dinkeloo ● Lisa M. McKenzie ● John L. Adgate - Measuring environmental noise from airports, oil and gas operations, and traffic with smartphone applications: laboratory and field trials, Received: 9 January 2018 / Revised: 27 July 2018 / Accepted: 6 September 2018

[2] Chucri A. Kardous and Peter B. Shaw - Evaluation of smartphone sound measurement applications, Published Online 21 March 2014

[3] Travis McLennon, Shivangi Patel, Alberto Behar & Mohammad Abdoli- Eramaki - Evaluation of smartphone sound level meter applications as a reliable tool for noise monitoring, Published online: 29Jul 2019.

[4] Titus S. Ibekwe, David O. Folorunsho, Enoch A. Dahilo, Ibeneche O. Gbujie, Maxwell M. Nwegbu &Onyekwere G. Nwaorgu - Evaluation of mobile smartphones app as a screening tool for environmental noise monitoring, Published online: 08 Jan 2016.

[5] Gaetano Fava,Gisele Oliveira, Melody Baglione, Michael Pimpinella, and Jaclyn B. Spitzer - The Useof Sound Level Meter Apps in the Clinical Setting, published on February 2016

[6] Daniel R. Nast, William S. Speer, Colleen G. Le Prell - Sound level measurements using smartphone apps‖:Useful or inaccurate? Noise & Health, September-October 2014, Volume 16:72, 251-256

[7] Benjamin Roberts, Chucri Kardous & Richard Neitzel - Improving the Accuracy of Smart Devices toMeasure Noise Exposure, Published online: 10 May 2016.

[8] Sataloff RT, Sataloff J. Occupational Hearing Loss. 3rd ed.New York, NY: Taylor & Francis; 1996.

[9] National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard: Occupational Noise Exposure. Cincinnati, OH: U.S. Department of Health and Human Services, NIOSH;1998. Publication No. 98–126

[10] Murphy E, King EA. Testing the accuracy of smartphones and sound levelmeter applications for measuring environmental noise. Appl Acoust 2016

[11] Sinclair A, Smith TA. A three-frequency audiogram for use in industry. Br JInd Med 1984;41:401- 405.

[12] Rabinowitz PM, Galusha D, Dixon-Ernst C, Slade MD, Cullen MR. Do ambient noise exposure levels predict hearing loss in a modern industrial cohort? Occup Environ Med 2007.

[13] Fligor BJ. iPhone sound level meter apps. January 11, 2010

[14] Méndez Sierra J.A,Vílchez Gómez, R., Rubio García, A.O. Validation for Smartphone Applications for Measuring Noise, October 2016

[15] David C. Byrne & Efrem R. Reeves Analysis of Nonstandard Noise Dosimeter Microphone Positions, January 2008

[16] Benjamin Roberts , Richard Lee Neitzel Using Smart Devices to Measure Intermittent Noise in the Workplace

[17] Chucri A. Kardous Use of smartphone sound measurement apps for occupational noise assessments, 2015

[18] Rajiv Kumar , Abhijit Mukherjee, V P Singh Traffic Noise Mapping of Indian Roads Through Smartphone User Community Participation

[19] Enda Murphy , Eoin A King Smartphone-based Noise Mapping: Integrating Sound Level Meter AppData Into the Strategic Noise Mapping Process

[20] Eleanor Crossley , Tim Biggs The Accuracy of iPhone Applications to Monitor Environmental NoiseLevel.