LatIA. 2025; 3:323
doi: 10.62486/latia2025323
ISSN: 3046-403X

ORIGINAL

AI-assisted abnormal CXR findings and correlation with behavioral risk factors: A Public Health Radiography approach to formulating policies and effective interventions

Hallazgos CXR anormales asistidos por IA y correlación con factores de riesgo conductuales: Un enfoque de la radiografía de salud pública para formular políticas e intervenciones eficaces

Victor Chigbundu Nwaiwu[1], Sreemoy Kanti Das[2]

[1]Lincoln University College, Radiography department. Petaling Jaya, Malaysia.
[2]Lincoln University College, Pharmacology department. Petaling Jaya, Malaysia.

Cite as: Chigbundu Nwaiwu V, Kanti Das S. AI-assisted abnormal CXR findings and correlation with behavioral risk factors: A Public Health Radiography approach to formulating policies and effective interventions. LatIA. 2025; 3:323. https://doi.org/10.62486/latia2025323

Submitted: 12-01-2024 **Revised:** 18-07-2024 **Accepted:** 12-05-2025 **Published:** 13-05-2025

Editor: PhD. Rubén González Vallejo

Corresponding Author: Victor Chigbundu Nwaiwu

ABSTRACT

Introduction: cardiovascular, respiratory and related diseases (CVRDs) constitute over 40 % cause of death worldwide, mostly reported in low-and-middle-income countries. The catastrophic effect of this spans across poor health outcomes, severe economic loss and significant societal consequences. Responding to this situation necessitates collective strategy to prevent further deterioration as these conditions are closely related, share common risk factors as well as control measures at the clinical, population and policy levels. Thus, this study is aimed at understanding the distribution of AI-assisted abnormal adult chest X-ray (CXR) and examine relationship with behavioral factors; to lay foundation for planned interventions.
Method: prospective mixed-methods research, cross-sectional in nature, conducted across six top-rated hospitals in Nigeria, representing the six geopolitical zones of the country via purposive sampling technique. Quantitative aspect involved data collection on demographics and abnormal findings from AI-assisted technology, while Qualitative aspect explored individual's behavioral choices in relation to risk factors. Informed consent and ethical approval were obtained; SPSS software utilized for descriptive and correlation analysis.
Results: cardiomegaly (15,35 %), pleural effusion (14,03 %), fibrous opacities (10,43 %), pleural capping (8,51 %), pulmonary mass (7,91 %), apical opacities (7,55 %), consolidation (6,59 %), infiltration (5,88 %) among the sixteen abnormal findings in decreasing order of magnitude. An early onset of these anomalies at 30 years was noted, hitting peak values at 40-44 years. A significant percentage of the population engages in unhealthy lifestyle, found to positively correlate with these anomalies in varying degrees; low education levels, health education gaps, poor income and environmental challenges clearly seen.
Conclusions: a Public Health Radiography approach- AI assisted, engaging with empirical evidence provides a novel and valuable strategy in designing effective interventions and policy making to address CVRDs burden.

Keywords: Artificial Intelligence; Abnormal Chest X-Ray; Behavioural Risk Factors; Public Health Radiography; Policies; Interventions.

RESUMEN

Introducción: las enfermedades cardiovasculares, respiratorias y afines (CVRD) constituyen más del 40 % de las causas de muerte en todo el mundo, sobre todo en los países de renta baja y media. Su efecto catastrófico

se extiende a los malos resultados sanitarios, las graves pérdidas económicas y las importantes consecuencias sociales. Para hacer frente a esta situación es necesaria una estrategia colectiva que evite un mayor deterioro, ya que estas enfermedades están estrechamente relacionadas y comparten factores de riesgo comunes, así como medidas de control a nivel clínico, poblacional y político. Por lo tanto, este estudio tiene como objetivo comprender la distribución de las radiografías de tórax (RXT) anormales en adultos asistidos por IA y examinar la relación con los factores de comportamiento; para sentar las bases de las intervenciones planificadas.
Método: investigación prospectiva de métodos mixtos, de carácter transversal, realizada en seis hospitales de primera categoría de Nigeria, representativos de las seis zonas geopolíticas del país, mediante una técnica de muestreo intencional. El aspecto cuantitativo consistió en la recopilación de datos sobre demografía y resultados anormales de la tecnología asistida por IA, mientras que el aspecto cualitativo exploró las opciones de comportamiento del individuo en relación con los factores de riesgo. Se obtuvieron el consentimiento informado y la aprobación ética; se utilizó el software SPSS para el análisis descriptivo y correlacional.
Resultados: cardiomegalia (15,35 %), derrame pleural (14,03 %), opacidades fibrosas (10,43 %), tapón pleural (8,51 %), masa pulmonar (7,91 %), opacidades apicales (7,55 %), consolidación (6,59 %), infiltración (5,88 %) entre los dieciséis hallazgos anormales en orden decreciente de magnitud. Se observó una aparición precoz de estas anomalías a los 30 años, alcanzando valores máximos a los 40-44 años. Un porcentaje significativo de la población lleva un estilo de vida poco saludable, que se correlaciona positivamente con estas anomalías en diversos grados; se observan claramente bajos niveles de educación, lagunas en la educación sanitaria, bajos ingresos y problemas medioambientales.
Conclusiones: un enfoque radiográfico de salud pública, asistido por IA y basado en pruebas empíricas, proporciona una estrategia novedosa y valiosa para diseñar intervenciones eficaces y formular políticas que aborden la carga que suponen las CVRD.

Palabras clave: Inteligencia Artificial; Radiografía de Tórax Anormal; Factores de Riesgo Conductuales; Radiografía de Salud Pública; Políticas; Intervenciones.

INTRODUCTION

Cardiovascular, respiratory and related diseases (CVRDs) amount to a significant cause of morbidity and mortality worldwide, accounting for over 10 % of all disability-adjusted life years and substantially contributing to excess health system cost;[1,2] Sub-Saharan Africa bearing a chunk of this burden.[3,4] In Nigeria for example, several studies across the country's geopolitical zones show that respiratory diseases are the main reason for between 8,7 % to 12 % of all hospital admissions, with high death rate.[5,6,7,8] Furthermore, cardiovascular diseases have led to in-hospital mortality of 8,1 % and an approximate overall 10 % of deaths.[9]

CVRDs share common risk factors such as age, genetics, tobacco use, poor diet, air pollution (exposure to dust, environmental fumes, asbestos, carbon-based cooking and heating fuels), physical inactivity, regular alcohol consumption, stress, occupational hazards, excess weight and obesity.[10,11,12,13] CVRDs burden in Nigeria calls for an evidence-based, innovative and interdisciplinary approach to achieve global sustainability and health equity, amidst cultural and religious diversity.[14,15]

Chest radiography, the first radiologic examination requested in patients with clinical findings suggestive of thoracic pathology,[16] do provide insights regarding assessment of the chest wall, mediastinum and hila including the heart and great vessels, lungs and pulmonary vasculature, pleural space including the fissures and diaphragm, central airways, soft tissues and bones. A careful and systematic assessment of these anatomic regions and structures (AI-assisted), as well as the technical quality of the image will produce a comprehensive evaluation and identification of subtle abnormalities.[17,18,19,20] Sadly, scanty information exists on the recent existing pattern of respiratory and cardiovascular diseases obtained from chest radiographs in Nigeria, with nil empirical evidence on its relation to behavioral risk factors; this is shocking given the substantiation of proof showing that modifications to unhealthy lifestyles are key determinants to CVRDs mortality and morbidity rates, Nigeria currently lacking local guidelines for managing cardiovascular and associated diseases.[9,21] A few documented studies recorded prevalence utilizing past data,[8,22] gotten via laboratory means,[2] while those using x-rays were either pathology/clinical indication specific[23,24,25] or retrospective in nature.[26,27]

Hence, this study, prospective in nature, seeks to evaluate the pattern of abnormal findings in adult chest radiographs in Nigeria and its correlation with behavioral risk factors. The outcome of this study and evidence-based illustrations made will provide strong supporting evidence to the government and its partners, international agencies, non-governmental organizations, healthcare professionals, medical team and healthcare providers in ensuring that proper planning, appropriate health policies and effective interventions are tailored to bring about the necessary changes amidst limited resources.

METHOD

Study setting: nigeria, the most populous African country with an area of approximately 923 768 sq, is situated in West Africa and divided into 6 geopolitical zones: North-Central (NC), North-East (NE), North-West (NW), South-West (SW), South-East (SE) and SouthSouth (SS). This Research was carried out in 6 selected health facilities depicting the 6 geopolitical zones of the country respectively. The radiology unit of these facilities possess a digital X-ray unit, Teleradiology application allowing for electronic sending of CXR images qure. ai software to assist with interpretation, and Picture archiving and communication system (PACS) for image storage and archiving purposes.

Study design and setting: this study, cross-sectional in nature employs mixed methods, integrating both qualitative and quantitative data.

Sample size: total sample size formulae for cross-sectional studies in medical research involving both quantitative and qualitative components as obtainable in the review article of [28] will be used. The calculation is given as follows.

$$N = \frac{Z_{1-\alpha/2}^{2}\, p(1-p)\ \text{(Quantitative)}}{(d)2} + \frac{Z_{1-\alpha/2}^{2}\, SD^{2}\ \text{(Qualitative)}}{(d)2}$$

Where: N- Total sample size.

$Z_{1-\alpha/2}$ - standard normal variate at 5 % type 1 error (P<0,05) is 1,96 and at 1 % type 1 error (P<0,01) is 2,58. Majority of studies considers P values significant below 0,05, hence 1,96 is used.

p - Expected proportion in population based on previous studies or pilot studies (abnormal chest x-rays, within 15-25 %, thus 20 % will be used).

d - Absolute error or precision (0,05 for quantitative and 5 for qualitative).

SD - Standard deviation of variable (20, approximated mean based on abnormal findings in previous studies).

$$N = \frac{1.96^2\ 0.20(1 - 0.20)}{20^2} + \frac{1.96^2}{(0.05)2}$$

52

N = 307

Sampling Technique: purposive sampling technique was carried in the selection of 6 health facilities to represent the 6 geopolitical zones of the country, thereby ensuring a fair representation of the entire population is achieved. Multiple stakeholders comprising cardiologists, respiratory specialists, radiologists, radiographers, health experts and policy makers very experienced in health care systems and delivery across local and national spheres of the federation were consulted, and collectively involved in this selection exercise to reduce bias. Certain factors otherwise known as characteristics stood out as key deciding markers in this targeted approach to maintain transparency and integrity; these include a very busy facility, affordability, hospital ratings/ reviews, reputability and commitment to excellence. All team members conjointly partook in drafting a list of possible hospitals meeting these characteristics per geopolitical zone, followed with rating by each team member, and the facility with the highest score emerged to represent the zone.

Participants: the sample size was shared equally among the six health facilities participating in this research, implying approximately 51 study participants per health facility. Study respondents were patients visiting the radiology department for chest x-rays. To be eligible to participate, study respondents must be aged 18 years and above, as well as freely give consent for the brief interview session.

Approval and Ethical considerations: Approval was gotten from the hospital management board of the 6 selected health facilities to conduct this research. Having understood the goal of this study in developing planned actions to address CVRDs and the barrier distance/ associated cost may pose to achieving this, each hospital promised granting the appeal to produce a residing radiographer and radiologist willing to participate in this research. Several ethical principles were upheld such as voluntary participation of radiographers and radiologists, anonymity when collecting data from CXR reporting sheet and informed consent for the interviews. In addition, making use of consulting rooms to achieve privacy, and engaging a doctor in the facility to obtain honest responses and ensure confidentiality is maintained between the radiologist and the patient during interview sessions.

Research Team: the overall research team of 13 team members consists of a lead researcher, research radiologists and research radiographers, each of not less than three years of clinical experience. Every participating facility produced a research radiographer and a research radiologist, volunteering to participate in this study and working at the respective facility, both reporting remotely to the lead researcher. Series of virtual trainings and capacity building meetings was organized to keep team members on par and set everyone on gear, including holding joint remote image viewing sessions for radiologists on qure.ai software use.

Procedure: the research was conducted in two phases: quantitative and qualitative, involving patients with a CXR request and visiting the radiology department in the individual facilities of study.

a) Quantitative aspect: as routine clinical practice demands; the research radiographer performed CXR examination on patients visiting the radiology department in the respective facility of study using digital x-rays. Images were sent electronically to the hospital-bound radiologist, who in turn made use of the newly installed AI- assisted software (qure.ai) for reporting. On the teleradiology application, the radiographer filtered interpretation to show only abnormal results, downloaded this report and documented the hospital number, demographic information and abnormal findings from the chest x-ray reporting sheet. Thereafter, proceeded to hand over the CXR result sheet to the patient and follows up with them to see the research radiologist for explanation of CXR report.

b) Qualitative aspect: the research radiologist, ought to be skilled in clerking, was saddled with holding a brief interview session in the consulting room with patients presenting abnormal CXR interpretation. The aim of the research was explained to the patient and informed consent obtained; the radiologist clearly outlining the need of obtaining honest responses and assuring the patient that confidentiality will be maintained. Vital questions were asked in a simplified manner on individual habits / behavior levels that surrounds dietary intakes (calories, as well as fruits), smoking and tobacco use, physical activity, alcohol use, environmental exposure to air pollution and daily water intake levels. Responses were documented in a sheet, with the patient's hospital number on it for easy matching. The research radiographer and radiologist reported daily to the lead researcher on the quantitative and qualitative aspect of research activity respectively.

Data collection: the lead researcher coordinated the overall data collection activity, working remotely with the research radiographers and physicians to assemble all results gotten from across the 6 hospitals into an excel sheet. Quantitative data to include age, sex, education, occupation and abnormal findings while qualitative data to give in-depth information on lifestyle choices.

Data Analysis: all data in the excel file was rechecked for accuracy before imported into the SPSS software (version 25) for descriptive and correlation analysis.

RESULTS

It can be seen that most chest X-ray abnormalities occur between ages 30-49, with age bracket 40-44 recording the highest.

Table 1. Age distribution of abnormal chest radiographs expressed in percentage

Age in years	No of respondents	Percentage
18-24	9	2,93
25-29	14	4,56
30-34	41	13,36
35-39	58	18,89
40-44	71	23,13
45-49	57	18,57
50-60	26	8,47
Above 60	31	10,10

These chest X-ray abnormalities are more prevalent in males than in females.

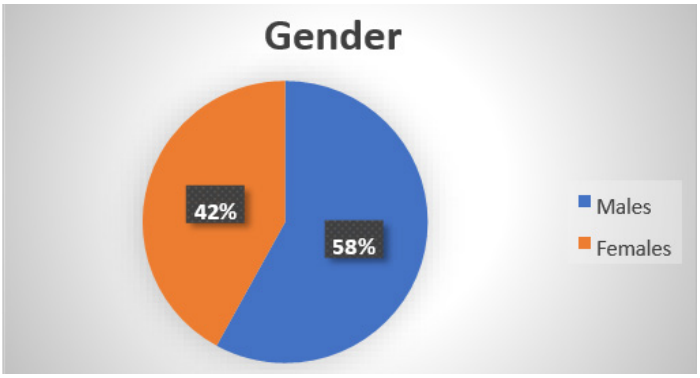

Figure 1. Sex distribution of abnormal chest radiographs, 178 males and 129 females expressed in percentage

The educational attainment for majority of the study population was secondary school, with existing levels of illiteracy, although a good proportion are graduates.

Table 2. Education levels of study respondents expressed in percentage

Education level	No of respondents	Percentage
No formal education	33	10,75
Primary education	52	16,94
Secondary education	113	36,81
Tertiary education	98	31,93
Postgraduate level	11	3,58

Most of the population engage in business and trade, significant levels of unemployment well noted.

Table 3. Occupation of study respondents expressed in percentage

Occupation	No of respondents	Percentage
Student	13	4,23
Skilled trade	53	17,26
Businessman /woman	92	29,97
Industry	29	9,45
Civil servant	31	10,10
Unemployed	35	11,40
Retiree	27	8,79
Farming	27	8,79

16 anomalies were demonstrated in varying degrees of prevalence, cardiomegaly and blunted/obliterated costophrenic angle making the headlines.

Table 4. Abnormal findings in chest radiographs expressed in percentage

Abnormal findings	Appearances	Percentage
Blunted /obliterated costophrenic angle	117	14,03
Apical opacities	63	7,55
Pulmonary nodule/mass	66	7,91
Pleural capping	71	8,51
Cardiomegaly	128	15,35
Consolidation	55	6,59
Fibrous opacities/streak/scar	87	10,43
Hilar Lymphadenopathy	33	3,96
Infiltration	49	5,88
Cavitation	28	3,36
Fracture	19	2,28
Atelectasis	31	3,72
Interstitial fibrosis	18	2,16
Mediastinal mass	14	1,68
Collapsed lung/Pneumothorax	28	3,36
Mediastinal shift	27	3,24

Table 5. Behavioural lifestyle choices of study respondents expressed in percentage

i) Calorie intake levels in a day. Approximately 2/3rd of the population well exceeds the recommended daily calorie intake levels.			
Daily Calories intake levels (kcal)	1500-1999 for male & 1000-1499 for female (Low) 24 (7,82 %)	2000-2999 for male & 1500-2499 for female (Medium) 98 (31,92 %)	Above 3000 & 2500 for male & female respectively (High) 185 (60,26 %)
ii) Fruits and vegetables consumption. Again, more than half of the population do not consume fruits/vegetabkes/fruits at satisfactory levels, with merely just a fraction of the population meeting the daily required levels.			
Fruit and Vegetables intake levels (1,5-2 cups of fruits and 2-3 cups of vegetables)	Daily 17 (5,54 %)	Up to 5 times a week 44 (14,66 %)	Up to 3 times a week 70 (22,04 %)	Others 176 (57,33 %)
iii) Smoking/tobacco use. Approximately 2/3rd of the study population do not engage in smoking which is impressive, but also important to note that a significant percentage smoke regularly.				
Smoking / Tobacco use	Smoke regularly 93 (30,29 %)	Smoke occasionally 15 (4,89 %)	Use to smoke, but have Stopped 11 (3,58 %)	Never smoked 188 (61,24 %)
iv) Alcohol use. Here, the proportion of alcohol users to non-alcohol users in the study population is almost equal, a remarkable percentage of substance abusers recorded.				
Alcohol use	Regularly 106 (34,53 %)	Occasionally in little quantity 47 (15,31 %)	Use to take alcohol but have stopped 7 (2,28 %)	Doesn't take alcohol 147 (47,88 %)
v) Exposure to air pollutants e.g., asbestos, particulate matter, ozone, volatile organic compounds, Pb, CO, NO2, SO2, etc. Almost half of the population are subjected to air pollution at varying degrees, occurring at home, work place, business, school and the general environment.			
Exposure to air pollution (at home, nature of work/occupation risk, business, school or nearby surroundings)	Regularly 69 (22,48 %)	Occasionally 68 (22,15 %)	Not applicable 160 (52,12 %)
vi) Daily water consumption. Most of the study population do not meet the required daily wáter intake levels.			
Daily water intake	0-3,0 liters/day for male & 0-2,0 liters/day for female (Low) 177 (56,65 %)	3,1-3,7 liters/day for male & 2,1-2,7 liters/day for female (Medium) 118 (38,44 %)	Above 3,7 liters/day for male & 2,7 liters/day for female (High) 12 (3,91 %)
vii) Physical activity. Again, virtually the entire population do not engage in physical activity, with only a fraction reportedly exercising regularly.			
Exercise / fitness	Regularly 35 (11,40 %)	Occasionally 41 (13,36 %)	No exercise 231 (75,24 %)

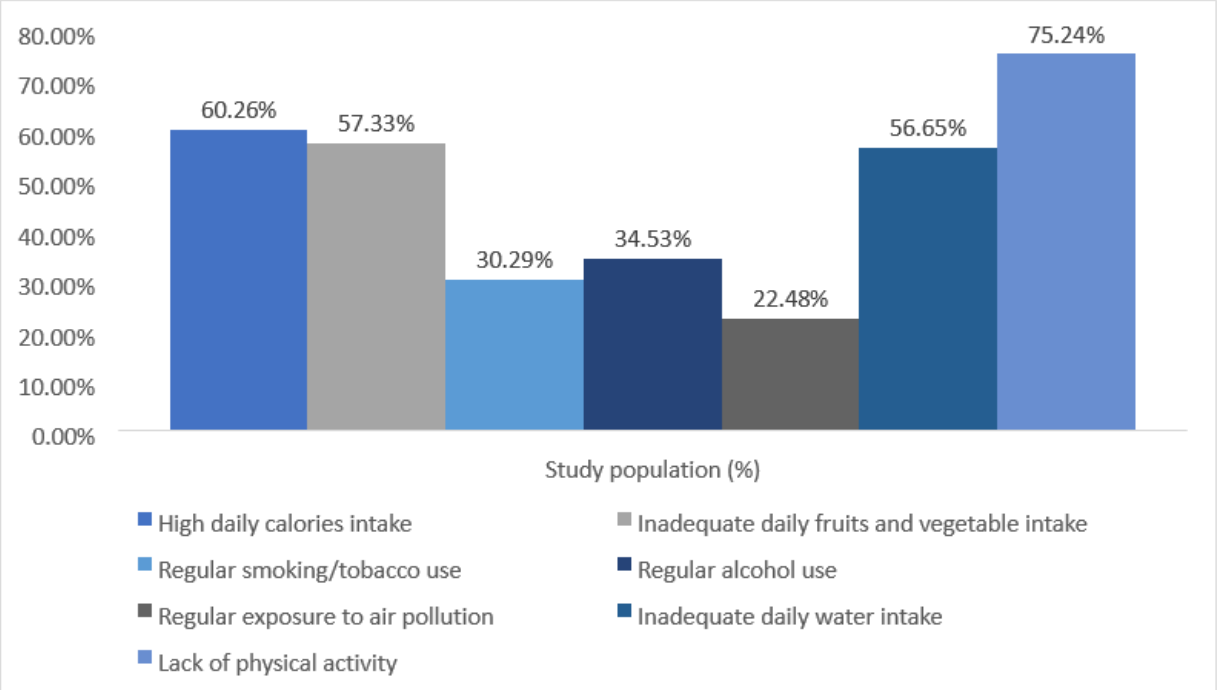

Figure 2. Behavioural risk factors and percentage of study respondents

In general, the pattern reveals non-healthy life style choices of majority of the populace.

Table 6. Correlation analysis of common abnormal findings (above 5 %) in chest radiographs and behavioral risk factors [0,80-1,0 (Very strong), 0,60-0,799 (Strong), 0,40-0,599 (Medium), 0,20-0,399 (Weak), 0,00-0,199 (Very weak)]

		Correlation Analysis						
	CXR anomaly	High Daily Calories intake	Inadequate daily fruits and vegetable intake	Regular smoking / tobacco	Regular alcohol use	Regular Exposure to air pollution	Inadequate daily water intake	Lack of physical activity
1	Blunted/obliterated costophrenic angle	0,269	0,318	0,807	0,793	-0,022	-0,011	0,466
2	Apical opacities	-0,022	-0,043	0,381	-0,012	0,514	-0,192	-0,035
3	Pulmonary nodule/ mass	-0,334	-0,182	0,826	0,662	0,723	-0,217	-0,123
4	Pleural capping	0,471	-0,037	0,324	-0,109	0,849	-0,055	-0,236
5	Cardiomegaly	0,951	0,894	-0,265	0,904	-0,013	-0,003	0,939
6	Fibrous opacities/ streak/scar	0,912	0,523	0,873	-0,215	0,758	0,364	0,332
7	Consolidation	0,573	0,402	-0,021	0,293	-0,105	0,906	0,591
8	Infiltration	-0,205	0,511	-0,322	0,781	-0,181	0,445	0,573

DISCUSSION

Principal findings and comparison with prior work: chest abnormalities seems to be more evident among the young and middle-aged adults' group population (30-49 years), cumulatively amounting for 73,95 % (table 1). This current significant finding tends to differ from a 5-year review study in 2021 (2015-2020) carried out in Nigeria in which the older adults aged 50-59 had the majority of chest anomalies.[27] The fact that these anomalies now significantly start at 30 years, often seen as the beginning of adulthood, and hitting peak levels 40-44 years calls for concern and swift action. Similar finding was reported at Malawi following conducted research in 2021.[29] Such trend does not promote healthy aging, a contemporary challenge facing population health globally. Furthermore, a slightly higher fraction of male to females was recorded in this study, in the ratio 1,38:1 respectively (figure 1). In addition, only 31,93 % of study respondents are educated to first degree level, with a chunk being secondary school holders (table 2). This statistic depicts low education levels in Nigeria, which is in line with findings from recent studies assessing educational attainment levels of Nigeria population and progress towards global agenda 2030 for education (SGD 4).[30,31] It is surprising that the occupation of nearly 48 % of study population is business and trade (table 3), agreeing with reports from national bureau of statistics[32] and a notable fraction of 11,40 % unemployed.

Sixteen findings in abnormal chest radiographs were documented (table 4), and common anomalies 5 % and above in order of decreasing appearance are cardiomegaly (15,35 %), blunted/obliterated costophrenic angle otherwise called pleural effusion (14,03 %), fibrous opacities/ streak/scar (10,43 %), pleural capping (8,51 %), pulmonary nodule/mass (7,91 %), apical opacities (7,55 %), consolidation (6,59 %), infiltration (5,88 %) in order of decreasing frequency. A quick look at this chart of anomalies reveals cardiomegaly and pleural effusion closely top the list, with this entire chart somewhat agreeing to findings within same population in existing literature. Cardiomegaly was by miles the most frequent chest X-ray finding (47,4 %) amidst seventeen others, pleural effusion (5,3 %) inclusive in research conducted in Nigeria.[33] According to [34], pneumonia (14,81 %), pleural effusion (11,11 %), tuberculosis (11,11 %) among others were the most frequent cases in the abnormal chest x-ray test set, expressed in percentage. A slight twist to this was reported by [26], as hypertensive heart disease (26,84 %), pulmonary tuberculosis (12,11 %), cardiomegaly (5,78 %), and pleural effusion (4,21 %) scored the highest under the abnormal category. In the study of [27], chest infection (64,75 %) was reportedly the leading chest finding down the anomaly lane, followed by hypertensive heart disease (16,99 %). Chest infection, an infection of the lungs or airways is a broad term that encompasses a range of anomalies, mostly pneumonia, tuberculosis and bronchitis. In the present study, pleural effusion as well as findings in the charts' lower mark (opacities, consolidation and infiltration) are closely known to be associated with tuberculosis and pneumonia infections.[35] A quick comparison of study findings to conducted studies outside Nigeria shows real similarities. Cardiomegaly was the commonest chest X-ray anomaly (20,7 %) in research conducted at Malawi.[29] Elsewhere in Netherlands, cardiomegaly (58,95 %), aortic elongation (20 %), chronic obstructive pulmonary disease (15,79 %), pleural effusion (7,37 %) and pulmonary /mediastinal mass (7,37 %) were among the widespread calculated anomalies.[36]

Again, this research clearly reveals the unhealthy lifestyle choices of the population, and the figures quite worrying (table 5). Only 39,74 % meets the required daily calorie intake levels. In same vein, just a handful 5,5 % fulfils the daily fruits and vegetables requirement for a healthy living. To worsen matters, a significant 30,29 % and 34,53 % smoke and drink regularly respectively. There is evidence of approximately 45 % population exposure to air pollutants in varying degrees, and not up to half of the population (42 %) meets the adequate amount of water daily. Sadly, just 11,40 % regularly engage in exercise. Figure 2 presents a summary of the percentage of study respondents engaging in the abovementioned unhealthy lifestyle, which themselves are the behavioral risk factors for CVRDs. Similar recently conducted population studies across the world agree with these statistics, showing a significant percentage engaging in the above unhealthy behaviors generally such as in Sweden[37] Vietnam,[38] Korea[39] and Nigeria.[40] Of interest in evidence conducted across various geopolitical zones of Nigeria is the even higher registered rates for smoking, drinking, calories intake and exposure to air pollution well exceeding WHO guidelines, including a significant percentage of physically inactivity in Nigeria following a systematic review and meta-analysis- 92,5 % smoking and 71,5 % alcohol;[41] 63,8 % smoking;[42] 66,7 % alcohol;[43] 94,53 % high calories;[40] 94 % exposure to air pollution;[44] 52 % physically inactive persons.[45]

Table 6 represents the correlation analysis of frequent chest findings with behavioral factors. A very strong positive coefficient exists between high calories intake and cardiomegaly and fibrous opacities/steak/scar, but moderately positive with consolidation. According to [46], excessive weight gain due to high calories consumption gives the body volume, making the heart pump blood harder than usual. It also causes extreme fat to build up in the airways resulting in fibrotic changes in the lungs, pulmonary infections and impair respiratory function.[47] Furthermore, a diet rich in fruits and vegetables has proven to greatly reduce the risk of heart disease and promote healthy lungs; with an accompanying 8 % reduction in pulmonary disorders (obstruction, blood clots, etc.) and lung cancer.[48,49] No wonder a strong positive existing relationship between inadequate fruit/vegetable consumption and cardiomegaly, and moderate positive relationships with infiltration, consolidation and fibrous opacities. Additionally, regular smoking strongly positively correlates with pulmonary mass, pleural effusion and fibrous opacities. This seems to be consistent with previous research, tobacco use associated with 5-10 % idiopathic pulmonary fibrosis and alveolar wall fibrosis,[50,51] pulmonary nodules[52] and pleural effusion ($p<0,0001$).[53] In same vein, a powerful positive correlation between regular alcohol use and cardiomegaly, whereas a good correlation with infiltration and blunted/obliterated costophrenic angle. This relation is consistent with a recent 2024 update and case report: prolonged alcohol intake resulting in an aftermath pleural effusion effect,[54] cardiomyopathy,[55] pulmonary inflammations and increase collagen accumulation.[56] In addition, exposure to air pollutants strongly positively correlates with pleural capping, fibrosis opacities and pulmonary nodules. This assertion seems valid, with literatures revealing association of air pollutants such as asbestos with thickening of membranes surrounding the lungs (pleura), pleural fibrosis (scaring) and elevation of pulmonary nodule prevalence by 1,040, 1,314 and 1,021 (organic matter, black carbon and NO_3 pollutants respectively).[57,58,59] Although, inadequate water consumption mostly negatively correlated with structural chest anomalies, systemic hydration has been discovered in the experimental study of [60] to have a positive effect on pulmonary function. Following a conducted systemic review and meta-analysis,[61] reported subsequent reduction in healthcare use and pneumonia mortality in adults as a result of >1,5L/day water consumption. This claim agrees with current study, a very strong positive correlation of water consumption with consolidation (mostly known as pneumonia) noted. Lastly, lack of physical activity is seen to positively correlate highly with cardiomegaly, and moderately with consolidation, infiltration and pleural effusion. In the studies of [62,63] exercise was found to be regulators of systemic inflammation, linked with weight loss, increase cardiac output, reduction in blood pressure and lower cardiac hypertrophy. Cristina et al.[64] discovered decrease in oxidative stress due to physical activity, which has an anti-inflammatory effect, causing a reduction in upper respiratory infections. This is well supported by [63], observing that as activity decreases, weight increases, and lung function is negatively affected.

Implications for practice and policy

Several population-based studies reveal several interrelated factors, which are part of social determinants of health, responsible for such abysmal behavioral lifestyle choices such as poor income, unemployment, low education, environmental influence, stress /mental disorders and the government.[65,66] Evidence-based practice implies that actions are taken to address these factors, relying on credible scientific research, clinical data and population preferences to improve health outcomes.

The current study reveals three key markers to be taken into consideration. The first is low level of education and possible existing health knowledge gap, with majority being business/skilled traders. According to [67,68], low levels of education and decrease socioeconomic status contributes to physical inactiveness, substance misuse and high calories intake. In our contemporary society marked with educational inequalities, efforts in public health are instead channeled towards improving health knowledge of the populace to make the right choices. Nevertheless, we are currently witnessing a paradigm shift in approach due to technology. The rapid

growth of digital technologies has today created the opportunity for personalized preventive health education interventions, totally transforming the field of health promotion, and making health services more accessible and effective worldwide at little or no cost.[69,70] Interestingly, Nigeria is home to approximately 31,60 million social media users as of 2023, and a further 85,49 million have internet access (42 % of the population), social media use projected to increase by more than 80 % between 2019 to 2025.[71,72,73] Age and educational levels are known factors in determining the adoption and sustained use of technology.[74] Documented evidence across Europe, Asia, Africa, North America and Oceania has all proven that younger age and higher education levels are associated with a higher degree of acceptance, based on the technology acceptance model (TAM).[75,76,77] This seems to deeply resonate with planned actions following results of this study, as the younger population are mostly affected with chest abnormalities. However, low education levels recorded may look to pose a significant hurdle, and improving the digital heath literacy in those with lower educational attainment can constitute a major challenge; one to observe closely, map out, formulate and accomplish accordingly.[78] Recent literatures, adopting technology as a tool for health promotion and intervention has yielded promising results in varying degrees, utilizing various strategies. This includes providing online platforms for health education, interactive applications, social media, personalized monitoring and remote healthcare delivery. We shall briefly consider these approaches each in a tabular form, sighting studies. Planned technological interventions should be designed to promote health literacy and education, tailored towards addressing specific concerns such as nutrition, exercise, substance abuse cessation and water consumption. Recognizing individual study limitations will serve as a guide in setting up a better and effective design/framework.

Platforms for health education: this entails use of user-friendly mobile apps to provide health information, symptom checkers and educational content. In addition, creation of websites and online for health news, disease prevention guidelines and interactive tools for self-assessment.

Table 7. Analyzed Studies

No	Description	Results	Limitations
1. [79]	A systematic literature review on Mobile app-based health promotion programs.	Health outcomes better for mobile app users compared to nonusers.	Feasibility and effectiveness of mobile apps in developing countries be explored.
2. [80]	DigiAdherence mobile app consisting of short video and health messages in Portugal.	Was useful, user friendly and highly accepted.	Selection bias (high digital literates with access to ICT), app was exclusive to only android, high storage space of app due to its offline nature.
3. [81]	Walker and Avant's mobile app model.	Efficiency, user satisfaction and learnability	Only English language, Health care professionals' perception on its usability and association with health outcomes lacking.
4. [82]	A systematic review on app-based health promotion interventions on modifiable risk factors.	Mobile app an effective tool to improve health knowledge promoting healthy habits.	Further apps be developed on evidencebased behavior change techniques and incorporate gamification features to further boost effectiveness and engagement.

Social media: employs platforms such as Facebook, Twitter, Instagram, WeChat, YouTube, etc. as a means of disseminating heath information and interventions, facilitating communication between providers and patients, raise awareness level, and encourage behaviors change via interactive features and community engagement.

Table 8. Analyzed Studies

No	Description	Results	Limitations
1. [83]	Systematic review on social media use for health.	Twitter, Facebook, WeChat, Youtube, Reddit, Online forums, WhatsApp, Instagram among the commonest; very useful in sharing health-related information, creating online community of support, tracking/sharing health activities.	Gaps such as understanding the impact of health identity development and addressing privacy concerns.
2. [84]	An Integrative review on potential of social media in health promotion.	Facebook and YouTube more used for intervention purposes while Twitter and Instagram for observing trends; social media having the potential in promoting behavior change, adopting social cognitive theory and transtheoretical model.	Most evidence uses social media for communication rather than education to evaluate behavior change. Studies should incorporate some theories of behavior change in social media interventions to monitor shifts

			in stages of behavior change and evaluate sustainability of outcomes.
3. [85]	A Cochrane review summary with commentary on effectiveness of interactive social media in changing health behaviors.	Interactive social media interventions showing promising results on physical activity, weight loss, and tobacco use, dietary behavior and well-being. using broad user base platforms Facebook and Instagram, and making use of Pinterest ads.	Extensive heterogeneity of the evidence and small effects. Role of mediating variables be examined to better understand the mechanism of social media interventions and adherence measured.
4. [86]	Evolving role of social media in health promotion.	A range of tools social media offers such as influencer marketing, usergenerated content, social media monitoring, and online health communities. Platforms are Facebook, Twitter, YouTube, LinkedIn, and TikTok.	Lack of regulation, privacy concerns, limited engagement and ever-changing social media algorithms

Personalized monitoring and remote healthcare delivery: this mostly involves wearable devices for tracking vitals, activity levels and fitness. In addition, telemedicine which enables online consultations with healthcare providers for advice and follow-ups.

Table 9. Analyzed Studies

No	Description	Result	Limitations
1. [87]	A comprehensive evaluation of the impact of telemedicine and remote patient monitoring.	Prospective observational study revealed improve patient health, decrease diseasespecific markers, increase satisfaction with communication, improve accessibility to healthcare services, and decrease in frequency of healthcare utilization.	
2. [88]	Unveiling the potential of remote monitoring and telemedicine.	Fosters patient engagement and selfmanagement, as patients are able to monitor fluid intake, adopt lifestyle modifications, reduce hospitalization, gain access to health education /care and reduction in health cost. AI-driven models able to predict individual patient trajectories and offer personalized interventions.	Technical challenges such as access to internet connectivity and advanced technology, digital literacy, data privacy and security concerns, and health illiteracy.
3. [89]	Remote patient monitoring (RPM) intervention framework.	Patients feel more engaged, motivated and informed via messaging systems. Improves compliance and accessibility to care at reduced cost, measuring electrocardiograms, respiration rates, pulse oximetry, blood pressure, patient weight, sleep patterns, etc.	Limited internet access, low digital literacy, privacy and a secured transmission concerns to prevent unauthorized access, chance for bias in data analysis (from data itself, choice of features/variables and algorithmic biases)
4. [90]	Remote patient monitoring systems: architecture, applications and challenges.	Wireless sensors, wireless connectivity, and transmission of acquired data to hospital/ health practitioner components; very useful for vitals monitoring (heartrate, breathing rate, blood oxygen saturation), and diseases diagnostic monitoring, fostering more patient engagement and reduction in cost of care.	More efficient research in remote patient monitoring system by way of extending lifespan of sensor devices to improve clinical decision making, self-management and adherence to care plans.

The second point is poor economy and a significant level of unemployment; the government unable to provide jobs and many forced into starting up small businesses, trade and farming. Higher income levels result in purchase of fruits of vegetables. Unemployment and mental stress are often times associated with smoking and excessive alcohol use.[91] In a recent scoping review of [92], most attention is given to behavioral health promotion and prevention perspectives and gaps continue to persist on the structural perspectives such as laws, regulations and built environment that help individuals make healthy choices. Therefore, advocating for policies and community-based programs to support economic stability and social safety, adopting culturally sensitive approaches and community engagement is one measure that will create opportunities, better income levels, improve lifestyle choices and boost health outcomes.[93,94] Regulating food marketing, non-alcoholic beverages and enacting laws on compulsory labelling the calories levels on food products has proven to help customers make healthier choices and access nutritious food.[95,96] Studies has consistently shown that raising

taxes for tobacco and alcoholic products effectively raises prices and reduces consumption levels.[97] Following a systematic review in 2024,[98] implementing food assistance programs, food subsidies on nutritional foods, education on budget-friendly healthy eating and food security initiatives tends to improve diet quality and boost the nutritional status of the population.

Exposure to air pollution makes up the third aspect, and the fact that almost half of the population being affected is worrying. In Nigeria, the national environmental (air quality control) regulations 2014 and 2021 set out provisions for controlling air pollution in homes, offices and public spaces.[99,100] The National Environmental Standards and Regulations Enforcement Agency (NESREA) Act of 2007 prescribes the mechanism for handling air pollution and wastes, as well as enforcing these laws.[101] Present study findings uncover gross level of negligence and noncompliance to these existing laws. Studies has demonstrated enforcement and close monitoring of clean air act policies to be linked with lowered level of air pollutants /toxic pollutants.

The study adopted mixed methods to gain more comprehensive and in-depth understanding of the research topic. Being able to conduct this study across the 6 political zones of the country makes study findings a good representation of the population and, offers a holistic basis to drive the needed change. Robust engagement with studies all over the world to acquire insights to addressing problem makes this research have real-world applicability across a range of settings.

CONCLUSIONS

Chest radiography remains a simple, cost-effective and useful first-line imaging tool for chest assessment, AI-assisted technology assisting clinicians in detecting 16 anomalies. Evidence of greater population involvement in unhealthy behaviors and demonstrable positive correlation with these anomalies in varying degrees seen. Engagement with sufficient evidence reveals the impact of technology, policies and enforcement of environmental laws in promoting healthier choices, following highlighted gaps across education, knowledge and environmental regulation. Understanding patterns of abnormal chest radiographs, behavioral choices of the population, and lessons drawn from practical case studies will lay the foundation to formulating policies and effective interventions.

BIBLIOGRAPHIC REFERENCES

1. Muthiah V, George AM, Justine VT, Valentin F, Gregory A. The Global Burden of Cardiovascular Diseases and Risk: A Compass for Future Health. Journal of the American College of Cardiology. 2022;80(25):2361-71.

2. Ojuawo OB, Desalu OO, Aladesanmi AO, Opeyemi CM, Azeez AT, Fawibe AE, et al. Outpatient Burden of Adult Respiratory Diseases in University of Ilorin Teaching Hospital, Nigeria. Nigerian Journal of Clinical Practice. 2022;25(8):1233-8. doi:10.4103/njcp.njcp_1864_21.

3. Burney P, Jarvis D, Perez-Padilla R. The global burden of chronic respiratory diseases in adults. The International Journal of Tuberculosis and Lung Disease. 2015;19(1):10-20.

4. Giovanni V, Sara M, Salvatore F, Sandra B. Global burden of chronic respiratory diseases. Journal of Aerosol Medicine and Pulmonary Drug Delivery. 2020;33(4):177.

5. Adeniyi BO, Awokola B, Irabor I, Obaseki DO, Ayeni EO, Alele BK, et al. Pattern of respiratory disease admissions among adults at Federal Medical Centre, Owo, South-West, Nigeria: A 5-year review. Annals of Medical and Health Sciences. 2017;7(1):96-101.

6. Adeoti AO, Fadare JO, Ajayi EA, Adekeye K, Akolawole MA. Respiratory-related medical admissions in a tertiary institution in South-Western Nigeria. J Gen Pract (Los Angel). 2018;6(352):2-8.

7. Desalu OO, Oluwafemi JA, Ojo O. Respiratory diseases morbidity and mortality among adults attending a tertiary hospital in Nigeria. Jornal Brasileiro de Pneumologia. 2009;35(1):745-52.

8. Umoh VA, Otu A, Okpa H, Effa E. The Pattern of Respiratory Disease Morbidity and Mortality in a Tertiary Hospital in Southern-Eastern Nigeria. Pulmonary Medicine. 2013;2013:581973. doi:10.1155/2013/581973.

9. Okechukwu SO, Olanike AO, Tomilola OJ. Cardiovascular Diseases in Nigeria: Current Status, Threats, and Opportunities. Circulation. 2023;148(19):1441-4. doi:10.1161/CIRCULATIONAHA.123.063671.

10. Vamadevan SA, David AW, Dorairaj P. Relationships among Major Risk Factors and the Burden of Cardiovascular Diseases, Diabetes, and Chronic Lung Disease. In: Prabhakaran D, Anand S, Gaziano TA, Mbanya

J, Wu Y, Nugent R, editors. Cardiovascular, Respiratory, and Related Disorders. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017. p. 8-20.

11. Leonard AK, Charles G, Mary I, Cemal O, James E, Peter H. The Importance of healthy lifestyle behaviors in the prevention of cardiovascular disease. Progress in Cardiovascular Diseases. 2022;70:8-15. doi:10.1016/j.pcad.2021.12.001.

12. Samantha GF, Mindy MK, Erick JF, Anagha AB, Gloria JG, Jacqueline ES. Psychological Treatment Considerations in Medical Comorbidity. In: Gordon JG, editor. Comprehensive Clinical Psychology. 2nd ed. Elsevier; 2022. p. 225-51. doi:10.1016/B978-0-12-818697-8.00195-3.

13. GBD 2019 Chronic Respiratory Diseases Collaborators. Global burden of chronic respiratory diseases and risk factors, 1990-2019: an update from the Global Burden of Disease Study 2019. eClinicalMedicine. 2023;59:101936. doi:10.1016/j.eclinm.2023.101936.

14. Daniel AN, Chinedum OE, Ukachukwu OA. Ischemic Heart Diseases in Nigeria: Exploring the challenges, current status, and impact of lifestyle interventions on its primary healthcare system. International Journal of Environmental Research and Public Health. 2022;19(1):211-5.

15. Rasheedat MI, Jubril AA, Mohammed BA, Abdul-Wahab BRJ. Burden and spectrum of pediatric respiratory diseases at a referral hospital in North-Central Nigeria- A five year review. African Journal of Emergency Medicine. 2020;10(1):3-7. doi:10.1016/j.afjem.2019.09.001.

16. Hwang EJ, Nam JG, Lim WH, Park SJ, Jeong YS, Kang JH, et al. Deep Learning for Chest Radiograph Diagnosis in the Emergency Department. Radiology. 2019;293(3):574-9. doi:10.1148/radiol.2019191225.

17. Mohsen S, Marzieh KM, Hanieh M, Sajad B, Razieh R, Zafar M, et al. Belief and Behaviors of Radiographers concerning Digital Chest Radiography: Importance of Training courses. Journal of Clinical Care and Skills. 2022;3(4):2-13. doi:10.21203/rs.3.rs-1806948/v1.

18. Sean CG, Michael JL. Current concepts in the staging of non-small cell lung cancer. Surgical Oncology. 2002;11(4):181-90. doi:10.1016/s0960-7404(02)00050-6.

19. Joshua B. Imaging the Chest: The Chest Radiograph. In: Joshua B, editor. Diagnostic Imaging for the Emergency Physician. W.B Saunders; 2011. p. 185-296. doi:10.1016/B978-1-4160-6113-7.10005-5.

20. Jeffrey SK, Melissa LR. A Systematic Approach to Chest Radiographic Analysis. In: Juerg H, Rahel AK, Gustav K, editors. Diseases of the Chest, Breast, Heart and Vessels 2019-2022: Diagnostic and Interventional Imaging. Cham (CH): Springer; 2019. p. 3-20.

21. Leila S, Mohammad AM, Eesa M, Seid S, Katayoun R, Mohammad HN, et al. Behavioral determinants of cardiovascular diseases risk factors: A Qualitative directed content analysis. ARYA Atheroscler. 2014;10(2):71-81.

22. Airenakho E, Oluwaseun RA, Blessyn OA, Asuwemhe JU, Mercy OD, Hannah OI, et al. Pattern and trends of respiratory diseases in an outpatient setting: a five-year review in a tertiary hospital in south-south, Nigeria. International Journal of Research in Medical Sciences. 2023;11(6):1919-25. doi:10.18203/2320-6012.jrms20231602.

23. Akhigbe R, Anthony CU, Michael PO, Beatrice UM, Bolaji IJ. Abnormal chest radiographic patterns in patients with pulmonary tuberculosis in Lagos State, Nigeria: A single center study. International Journal of Medical and Health Research. 2018;5(1):36-40.

24. Adewuyi SA, Arogundade R, Igashi JB, Chom ND, Hamidu AU, Campbell OB. The pattern of chest radiographs findings in metastatic cancer patients seen in a tertiary hospital in northern Nigeria. Niger Postgrad Med J. 2011;18(4):245-50.

25. Michael EA, Chisolum OO, Samuel JU. Patterns of plain Radiographic findings among patients with chest trauma in Awka, Nigeria. International Journal of Medical Research. 2018;7(6):123-8.

26. Abacha M, Ismail S, Sadiq AA, Umar A, Dahiru GA, Izge IY, et al. Chest X-ray findings among adult patients attending Usmanu Danfodiyo University Teaching Hospital Sokoto North-western Nigeria. Annals of Clinical and Experimental Medicine. 2020;1(2):144-7. doi:10.47838/acem.26011977.127122020.asmeda.1.12.

27. Igoh EO, Gabkwet EA, Balla Z, Iyua KO, Salaam AJ, Danjem SM, et al. Chest Radiography: A Review of 5-year findings in peripheral facilities in Jos, North-Central, Nigeria. African Journal of Biology and Medical Research. 2021;4(4):118-24. doi:10.52589/AJBMR-HDKKFW4D.

28. Jaykaran C, Tamoghna B. How to Calculate Sample Size for Different Study Designs in Medical Research? Indian Journal of Psychological Medicine. 2013;35(2):121-5.

29. Twabi H, Semphere R, Mukoka M, Chiume L, Nzawa R, Feasey H, et al. Pattern of abnormalities amongs chest X-ray of adults undergoing computer-assisted digital chest X-ray screening for tuberculosis in peri-urban Blantyre, Malawi: A cross sectional study. Trop Med Int Health. 2021;26(11):1427-37. doi:10.1111/tmi.13658.

30. Kawu AS, Akinrefon AA, Adeniyi IO. Variation in Educational Attainment Levels: Statistical Evidence from the Nigeria Demographics Health Surveys (2008, 2013 and 2018). International Journal of Development Mathematics. 2024;1(2):191-9. doi:10.62054/ijdm/0102.15.

31. Robert N, Mary F, Karia G, Michel R, Adeboye A, Bala Y. Progress towards global agenda 2030 for education SDG4 in Nigeria 2023. National Bureau of Statistics. Nigeria Labour Force Statistics Report Q4 2022 & Q1 2023. 2023:1-35.

32. Akinola R, Akhigbe A, Mohammed A, Jaiyesimi M, Osinaike O, Jinadu F, et al. Evaluation of routine chest X-rays performed in a tertiary institution in Nigeria. Int J Cardiovasc Res. 2014;3(4):2-6. doi:10.4172/2324-8602.1000178.

33. Ekpo EU, Egbe NO, Akpan BE. Radiographers' performance in chest X-ray interpretation: the Nigerian experience. Br J Radiol. 2015;88(1051):2-6. doi:10.1259/bjr.20150023.

34. Zia S. What to know about chest x-rays for tuberculosis (TB). Medical News Today. 2023.

35. Annemarie M, Linda M, Pim A, Willem J, Tim L, Ricardo P. Frequency of abnormal findings on routine chest radiography before cardiac surgery. The Journal of Thoracic and Cardiovascular Surgery. 2018;155(5):2035-8.

36. Leonie K, Marie L, Ceicilia B, Mai-Lis H, Lena V, Marju O, et al. Co-occurrence of unhealthy lifestyle behaviours in middle-aged adults: findings from the Swedish cardiopulmonary biolmage study (SCAPIS). Scientific Reports. 2024;14:22853. doi:10.1038/s41598-024-71092-0.

37. Lan TH, Thi NA, Tan T, Tien D, Binh N, Khue M, et al. Sex differences in clustering unhealthy lifestyles among survivors of Covid-19: latent class analysis. JMIR. 2024;10(1):2-5. doi:10.2196/preprints.50189.

38. Yoon P, Jeonghee L, Jae H, Aesun S, Jeongseon K. Dietary patterns and colorectal cancer risk in a Korean population. Medicine. 2016;95(25):e3759. doi:10.1097/MD.0000000000003759.

39. Mobolaji MS, Justice EE, Eniola AB, Rabiu IJ, Okechukwu SO, Oyediran EO, et al. Differentials in lifestyle practices and determinants among hypertensive adults from three geopolitical zones in Nigeria. Pan African Medical Journal. 2024;48:98. doi:10.11604/pamj.2024.48.98.40776.

40. Ogundeko TO, Bassi CK, Bakam CK, Ramyil MS, Toma B, Ogbole EA, et al. Ubiquity of alcohol and tobacco use among secondary school students in Bogoro- Bauchi state. WJPLS. 2020;6(2):51-9.

41. Victor L, Tiwatayo L, Samson A. Outdoor smoking in Nigeria: prevalence, correlates and predictors. BMC Public Health. 2019;19:1313. doi:10.1186/s12889-019-7601-8.

42. Obinna DO, Birinus AE, Obumneme BA, Mark E, Uchenna NI, Ijeoma NO, et al. Prevalence and pattern of alcohol use among adults in an urban slum in south east Nigeria. Open Journal of Psychiatry. 2019;9(2):179-91. doi:10.4236/ojpsych.2019.92014.

43. Okhumode HY. Particle (soot) pollution in Port Harcourt Rivers state, Nigeria- double air pollution burden? Understanding and tackling potential environmental public health impacts. Environments. 2017;5(1):2-5. doi:10.3390/environments5010002.

44. Davies A, Janet O, Asa A, Boni M, Nnenna E, Chiamaka O, et al. Epidemiology of physical inactivity in Nigeria: a systematic review and meta-analysis. J Public Health. 2022;44(3):595-605. doi:10.1093/pubmed/fdab147.

45. Joseph W, Chiara D, Irina C, Mary N. Obesity cardiomyopathy in sudden cardiac death: A distinct entity? A comparative study. JACC: Advances. 2023;2(5):2-8. doi:10.1016/j.jacadv.2023.100414.

46. Neeraj M, Georgios K. Respiratory complications of obesity: from early changes to respiratory failure. Breathe. 2023;19:220263. doi:10.1183/20734735.0263-2022.

47. Heiner B, Angela B, Achim B, Sabine E, Dirk H, Anja K, et al. Critical review: vegetables and fruit in the prevention of chronic diseases. European Journal of Nutrition. 2012;51(1):637-63. doi:10.1007/s00394-012-0380-y.

48. Joanna K, Larsson SC, Orsini N, Linden A, Wolk A. Fruit and vegetable consumption and risk of COPD: a prospective cohort study of men. Thorax. 2017;72(6):500-9. doi:10.1136/thoraxjnl-2015-207851.

49. Ana C, Juan S, Vanessa R, Lucia F, Nuria R, Maria E, et al. Smoking-related interstitial lung disease: a narrative review. Chronic Respiratory Disease. 2024;21:1-9. doi:10.1177/14799731241291538.

50. Celia S, Marcio R, Andre C, Barbara V, Rui C, Susana G, et al. Diffuse smoking-related lung diseases: Insights from a radiologic-pathologic correlation. Insights into Imaging. 2019;10:73. doi:10.1186/s13244-019-0765-z.

51. Shucai W, Fang X, Yanfang W, Han W, Mo W, Caixin Y, et al. Relevant risk factor ad follow-up of lung nodules in physical examination with low-dose CT screening. Iranian Journal of Public Health. 2023;52(2):350-9. doi:10.18502/ijph.v52i2.11888.

52. Pavit T, Rajeev M, Reshma K, Sanjeev K. Tobacco smoking as a risk factor for tuberculous pleural effusion: a case-control study. Global Health Epidemiology and Genomics. 2020;12:e1. doi:10.1017/gheg.2020.1.

53. Richard E, Lucy S, Mubashar I, Victoria A. Pleural effusion in a patient with previous alcohol excess. Breathe. 2024;20:240036. doi:10.1183/20734735.0036-2024.

54. Fernando D, Eric A, Pablo G. Alcoholic cardiomyopathy: an update. European Heart Journal. 2024;45(26):2294-305. doi:10.1093/eurheartj/ehae362.

55. Sloan AL, Isaac RC, Brianna MD, Madison BB, Cherise H, Natali N, et al. Chronic alcohol consumption dysregulates innate immune response to SARS-CoV-2 in the lung. eBioMedicine. 2023;97:104812. doi:10.1016/j.ebiom.2023.104812.

56. Cleveland Clinic. Asbestosis. 2024.

57. Gregory ML, Christopher MW. Pleural thickening: detection, characterization, and differential diagnosis. Seminars in Roentgenology. 2023;58(4):399-410. doi:10.1053/j.ro.2023.06.001.

58. Cao Y, Sun T, Wang Z, Lei F, Lin L, Zhang X, et al. Association between one-year exposure to air pollution and the prevalence of pulmonary nodules in China. J Breathe Res. 2023;17(3):2-6. doi:10.1088/1752-7163/accbe4.

59. Konstantinos M, Vasileios T, Ioannis P, Zoe D, Aggeliki K, Konstantinos G, et al. Effect of hydration on pulmonary function and development of exercise-induced bronchoconstriction among professional male cyclists. Advances in Respiratory Medicine. 2023;91(3):239-53. doi:10.3390/arm91030019.

60. Lee H, Asmaa A, Sarah A, Chizoba B, Julii B, Tracey B, et al. Effects of fluid and drinking on pneumonia

mortality in older adults: A systematic review and meta-analysis. Clinical Nutrition ESPEN. 2022;47:96-105. doi:10.1016/j.clnesp.2021.11.021.

61. Roberto C, Elizabeth A, Larry D, James A. Inflammation, physical activity, and chronic disease: An evolutionary perspective. Sports Medicine and Health Science. 2020;2(1):1-6. doi:10.1016/j.smhs.2020.03.004.

62. Matthew A, Aruni B. Cardiovascular effects and benefits of exercise. Frontiers in Cardiovascular Medicine. 2018;5:135. doi:10.3389/fcvm.2018.00135.

63. Hopkinson NS, Polkey MI. Does physical inactivity cause chronic obstructive pulmonary disease? Clin Sci (Lond). 2010;118(9):565-72. doi:10.1042/CS20090458.

64. Cristina O, Teresa L, Carmen R, Lorena S, Raquel P, Juan M, et al. Physical and social environmental factors related to co-occurrence of unhealthy lifestyle behaviors. Health and Place. 2022;75:102804. doi:10.1016/j.healthplace.2022.102804.

65. Michael TC, Ruth SS. The social determinants of mental health. Focus. 2015;13(4):2-6. doi:10.1176/appi.focus.20150017.

66. AlJohara M, Ambreen K, Turky H, Ali M, Riaz Q, Khaled M. Factors associated with an unhealthy lifestyle among adults in Riyadh City, Saudi Arabia. Healthcare. 2021;9(2):221-5. doi:10.3390/healthcare9020221.

67. Danaei M, Palenik CJ, Abdollahifard G, Askarian M. Social determinants of health and attempt to change unhealthy lifestyle: A Population-based study. International Journal of Preventive Medicine. 2017;8:88-90. doi:10.4103/ijpvm.IJPVM_106_17.

68. Ronald B, Idrissa B, Maaike F, Carole D, Philip VL, Samantha D, et al. e-Health interventions for healthy aging: a systematic review. Systematic Review. 2020;9:128. doi:10.1186/s13643-020-01385-8.

69. Agata F, Shannon H, Effy V. Global youth perspectives on digital health promotion: a scoping review. BMC Digital Health. 2023;1:25. doi:10.1186/s44247-023-00025-0.

70. Simon K. Digital 2023: Nigeria. Datareportal. 2023.

71. Akinola O, Karen A. Social media and the state: challenging the rules of engagement. ISS Africa. 2021.

72. Oluwadamilare A. 60% of Nigerians are still not connected to the internet and only about 10% are active on social media. Technext24. 2020.

73. Jiyeon H, Hyeyoung KP. Factors affecting the acceptability of technology in healthcare among older Korean adults with multiple chronic conditions: A cross sectional study adopting the senior technology acceptance model. Clinical Interventions in Aging. 2020;15:1873-81. doi:10.2147/CIA.S268606.

74. Sara C, Pablo S, Cristina F, Esperanza S, Isabel E, Sergio C. Factors associated with the acceptance of new technologies for aging in pace by people over 64 years of age. Int J Environ Res Public Health. 2022;19(5):2-15. doi:10.3390/ijerph19052947.

75. Adi A, Mostafa A, Khaled S. Technology Acceptance in Healthcare: A systematic review. Applied Sciences. 2021;11:10537. doi:10.3390/app112210537.

76. Jia Y, Jeremie S, Shruthi C, Beth S, Jarell J, Joanna M, et al. A cross sectional study of role of technology in health for middle-aged and older adults in Singapore. Scientific Reports. 2024;14:18645. doi:10.1038/s41598-024-68410-x.

77. Crystal M, Elizabeth T, Richard N, Leanne W, Tim S, Julia N, et al. Educational attainment and willingness to use technology for health and to share health information- The reimagining healthcare survey. International Journal of Medical Informatics. 2022;164:104803. doi:10.1016/j.ijmedinf.2022.104803.

78. Lee M, Lee H, Kim Y, Kim J, Cho M, Jang J, et al. Mobile app-based health promotion programs: A systematic

review of the literature. Int J Environ Res Public Health. 2018;15(12):2838-42. doi:10.3390/ijerph15122838.

79. Marta L, Ana R, David G, Nuno M, Andre V, Andreia C, et al. Usability and utility of a mobile app to deliver health-related content to an older adult population: Pilot noncontrolled quasi-experimental study. JMIR Form Res. 2024;8:e46151. doi:10.2196/46151.

80. Po-Jen K, Ching-Min C. Usability of mobile applications: a concept analysis in health promotion. Taiwan Journal of Public Health. 2022;41(2):142-55. doi:10.6288/TJPH.202204_41(2).110113.

81. Kamalapriya A, Liane B, Anna H, Alexander J, Emma G, Banu P, et al. App-based oral health promotion interventions on modifiable risk factors associated with early childhood caries: A systematic review. Front Oral Health. 2023;4:2-6. doi:10.3389/froh.2023.1125070.

82. Junhan C, Yuan W. Social media use for health purposes: Systematic review. Journal of Medical Internet Research. 2021;23:e17917. doi:10.2196/17917.

83. Atousa G, Maximilian C, Maria P. The potential of social media in health promotion beyond creating awareness: an integrative review. BMC Public Health. 2022;22:2402. doi:10.1186/s12889-022-14885-0.

84. Ina W, Meera V, Stephanie M. How effective are interactive social media interventions for changing health and health behaviors? A Cochrane Review summary with commentary. Research Triangle Park, NC: RTI Press; 2023. p. 2-7. doi:10.3768/rtipress.2023.rb.0034.2309.

85. Rajshri R, Jessica M. Evolving role of social media in health promotion. In: Bishan S, editor. Health Promotion- Principles and Approaches. Rijeka: IntechOpen; 2023. p. 10-126. doi:10.5772/intechopen.107637.

86. Vijaya K, Rama B, Manasi C, Kalikrishna V, Lakshmi M, Ramanarayana B. The impact of telemedicine and remote patient monitoring on healthcare delivery: A comprehensive evaluation. Cureus. 2024;16:e55534. doi:10.7759/cureus.55534.

87. Ju-Chi L, Chun-Yao C, Tzu-Hurng C, Chen-Ning L, Jin-Jer C, Wen-Rui H. Unveiling the potential: Remote monitoring and telemedicine in shaping the future of heart failure management. Life. 2024;14(8):936-42. doi:10.3390/life14080936.

88. Jennifer C, Stacie P, Amol J, Todd P, Eric K. An infrastructure framework for remote patient monitoring interventions and research. Journal of Medical Internet Research. 2024;26:e51234. doi:10.2196/51234.

89. Kegomoditswe B, Adamu M, Boyce S, Abid Y, Caspar L. Remote patient monitoring systems: Applications, architecture, and challenges. Scientific African. 2023;20:e01638. doi:10.1016/j.sciaf.2023.e01638.

90. Barbara AL, Tashara ML, June MT, Cindy WL. Biobehavioral factors that shape nutrition in low-income populations: A Narrative review. America Journal of Preventive Medicine. 2017;52(2):s118-26. doi:10.1016/j.amepre.2016.08.003.

91. Anna L, Cornelia G, Christoph D. Digital Health Promotion and Prevention in Settings: Scoping Review. Journal of Medial Internet Research. 2022;24:e21063. doi:10.2196/21063.

92. Lee A, Leung S. Health outcomes. In: Michalos AC, editor. Encyclopedia of quality of life and well-being research. Dordrecht: Springer; 2014. p. 2730-5. doi:10.1007/978-94-007-0753-5_1251.

93. National Academies of Sciences, Engineering and Medicine; Health and Medicine Division; Board on Population Health and Public Health Practice; Committee on the Review of Federal Policies that Contribute to Racial and Ethnic Health Inequalities. Federal Policy to Advance Racial, Ethnic, and Tribal Health Equity. Washington DC: The National Academies Press; 2023. doi:10.17226/26834.

94. Emma B, Lauren M, Michelle M, Juliet H, Angela B, Andrew J. Systematic review of the effect of polices to restrict the marketing of foods and non-alcoholic beverages to which children are exposed. Obes Rev. 2022;23:e13447. doi:10.1111/obr.13447.

95. Anna H, Joshua P, Fang Z, Anjali R, Steven L, Eric B, et al. Calories labeling and product reformulation: A longitudinal analysis of supermarket prepared foods. Am J Prev Med. 2021;61(3):377-85. doi:10.1016/j.amepre.2021.03.013.

96. Guillermo RP, Prabhat J, Willaim S, Alan F. Taxation of tobacco, alcohol, and sugar-sweetened beverages: reviewing the evidence and dispelling the myths. BMJ Global Health. 2023;8:e011866. doi:10.1136/bmjgh-2023-011866.

97. Katharine G, Kathleen K, Hannah H, Khawlah A, Emily C, Ashlea B, et al. Local food system approaches to address food and nutrition security among low-income populations: A systematic review. Advances in Nutrition. 2024;15(4):2-5. doi:10.1016/j.advnut.2023.100156.

98. Federal Republic of Nigeria Official Gazette. National Environmental (Air Quality Control) Regulations, 2014. Lagos: The Federal Government Printer; 2014. p. B827-50.

99. Federal Republic of Nigeria Official Gazette. National Environmental (Air Quality Control) Regulations, 2021. Lagos: The Federal Government Printer; 2021. p. B3345-77.

100. Environmental Law Research Institute. A Synopsis of Laws and Regulations on the Environment in Nigeria. 2021.

101. EPA. Progress Cleaning the Air and Improving Peoples's Health. 2024.

FINANCING

The authors did not receive financing for the development of this research

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Victor Chigbundu Nwaiwu.
Data curation: Victor Chigbundu Nwaiwu, Sreemoy Kanti Das.
Formal analysis: Victor Chigbundu Nwaiwu.
Research: Victor Chigbundu Nwaiwu, Sreemoy Kanti Das.
Methodology: Victor Chigbundu Nwaiwu, Sreemoy Kanti Das.
Project management: Victor Chigbundu Nwaiwu, Sreemoy Kanti Das.
Resources: Victor Chigbundu Nwaiwu.
Software: Victor Chigbundu Nwaiwu.
Supervision: Sreemoy Kanti Das.
Validation: Sreemoy Kanti Das.
Display: Sreemoy Kanti Das.
Drafting - original draft: Victor Chigbundu Nwaiwu.
Writing - proofreading and editing: Sreemoy Kanti Das.