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REVIEW

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The trends of mortality, aetiologies and risk factors of lower respiratory infections in Saudi Arabia from 1990 to 2021: results from the global burden of disease study 2021

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Abstract

Background Lower respiratory tract infections (LRIs) are the fourth leading cause of death globally, affecting all age groups and leading to over 2 million deaths annually. Saudi Arabia faces a significant burden from LRIs, affecting more than 15% of the population each year. This study aims to provide an overview of LRI mortality, etiologies, and risk factors in Saudi Arabia from 1990 to 2021.

Method Data on LRI mortality in Saudi Arabia from 1990 to 2021 were extracted from the 2021 edition of the Global Burden of Disease (GBD) Result Tool. The analysis encompassed mortality rates across all age groups, with particular emphasis on children under five and adults over 70. Four primary etiologies influenza, respiratory syncytial virus (RSV), Streptococcus pneumoniae, and Haemophilus influenzae type b (Hib) were examined, alongside 14 associated risk factors.

Results The total LRI deaths in Saudi Arabia decreased by 6% from 1990 to 2021, with a significant reduction observed among children under five years old (96%). In contrast, LRI mortality among adults over 70 increased by 16% during the same period. The age-standardized mortality rate decreased by 47%, with significant reductions in deaths associated with pneumococcus and RSV. However, risk factors, such as smoking and ambient particulate matter pollution, showed minimal declines or even increased mortality rates in older adults.

Conclusion Over the past three decades, Saudi Arabia has made significant progress in reducing LRI mortality, particularly among children under five. However, the increasing mortality rates among the elderly highlight the need for targeted interventions to address their unique vulnerabilities. Continued investment in public health infrastructure, vaccination coverage, and environmental health initiatives is essential for further reducing the burden of LRIs in Saudi Arabia.

Keywords Lower respiratory infection, Mortality, Burden, And Saudi Arabia

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Introduction

The lower respiratory tract infection (LRIs) includes bronchitis and clinically diagnosed pneumonia, represent the fourth leading cause of death in the word's estimate. LRIs are known to affect all age groups and account for more than 2 million annual deaths yearly worldwide. In 2019 alone, there were records of approximately 0.67 million death from such infections among children under five years and more than one million deaths among adults aged 70 years or older across the globe [1]. LRIs are the most common infectious cause of morbidity and mortality worldwide [2]. The major causative agents of LRIs are viral, including respiratory syncytial virus (RSV), parainfluenza virus, influenza virus, adenovirus, and coronavirus [3]. Bacterial agents also play important roles, such as Streptococcus pneumonia and Haemophilus influenzae type b (Hib), with streptococcus pneumonia estimated to be responsible for about half of all LRI-related deaths [3]. Although RSV is well known for pediatric infections, it is also considered a formidable pathogen among immunocompromised adult patients [4,5].

In Saudi Arabia, acute LRIs is a concerning public health condition that affects more than 15% of Saudi Arabia's population annually [5,6]. Seasonal epidemics of RSV commonly occur during the winter months in Saudi Arabia, with the possibility of reinfections contributing to these outbreaks[5]. One potential reason behind the elevated rate of LRI in Saudi Arabia is the presence of more than 11.9 million migratory workers from more than 100 countries [7]. The massive number of travelers from and to the hometown and the Kingdom of Saudi Arabia could be associated with an high number of new infectious agents [7]. Moreover, during the Annual Hajj and Umrah to Mecca and Medina, approximately 10 million Muslims from about 184 different countries gather into the small area in the world. The enormous ethnicity diversity in these huge compact clusters leads to difference in LRI rates [8]. Indeed, the most predominant isolated viruses are human rhinoviruses (hRVs), influenza viruses, and non-MERS human coronaviruses (hCoVs) [9]. Furthermore, according to the Saudi Arabia Ministry of Environment, Water, and Agriculture, Saudi Arabia ranks third in camel stock numbers among Arab countries, with 1.4 million heads. Camels are considered the virus's intermediate host of lower respiratory infections like MERS-CoV [10,11].

The World Health Assembly Resolution has encouraged all countries to implement the Global Action Plan for Prevention and Control of Pneumonia (GAPP) as a national priority. This GAPP has evidence-based policies and plans and eventually seeks annual progress reports to control the pneumonia cases [12]. Some of the protection methods begin early in the life of a person by providing exclusive breastfeeding, which showed a decrease in pneumonia cases by 23%. Also, appropriate complementary feeding and vitamin A supplementation were associated with a 6% and 23% respective reduction of mortality rates [12]. Vaccination against The Pneumococcal Conjugate Vaccine (PCV), measles, pertussis, Hib, and rotavirus proved to decrease pneumonia incidence [12] Moreover, hand hygiene, regular sanitizing of commonly touched surfaces, and cough etiquette are considered nonpharmaceutical treatments (NPIs) that are routinely recommended to minimize respiratory infections [13]. Nearly, 63.5% of people always covered their mouths and noses and stopped spreading infections when coughing or sneezing. Only 20% of people wear masks daily, while 40% only use them as a preventative measure in crowded areas [14] The adoption of non-prescription antibiotics (NPIs) to prevent respiratory infections is still in need of improvement. Public health campaigns and education efforts may be necessary to increase adoption. However, implementing effective prevention measures requires a comprehensive epidemiological assessment of the burden of LRIs in Saudi Arabia targeting most impacted population.

Few studies in Saudi Arabia have been focused on the fatal burden of disease of LRIs. Most of them were related to the Hajj season, mainly focusing on adult patients, with a limited study have addressed the impact on pediatric patients, a more vulnerable group with high mortality rates [5,7,15]. The study aims to provide a systemic overview of mortality, etiologies, and risk factors of LRIs in Saudi Arabia from 1990 to 2021. This study's findings could guide healthcare policies and interventions to reduce the fatal burden of LRIs in Saudi Arabia, identifying specific risk factors and etiologies contributing to high mortality rates in a population level for patients with different age.

Method

Data sources

Using the global burden of disease (GBD) result tool (2021 edition) https://www.healthdata.org/research-analysis/gbd, we gathered LRI deaths (number of deaths) and mortality (death rate per 100,000 people) by age group in Saudi Arabia from 1990 to 2021. The basis of the GBD estimates procedure is identifying numerous data sources for every illness or injury, including vital registration systems, verbal autopsy data, hospital records, survey data, and other epidemiological studies. The GBD's 2021 assessed indicators of health impact for 288 causes of death, 365 diseases, and 88 risk factors across 204 countries and territories, extend over 25 age groups and both sexes, from the year 1990 to 2021 [16]. For the estimation of LRI mortality, GBD used the Cause of Death Ensemble Model (CODEm), which explores a wide range of possible models to estimate trends in causes of death. CODEm

incorporates predictive covariates such as sociodemographic factors, healthcare access, and risk factor exposures to enhance model accuracy. The estimates undergo rigorous validation, including out-of-sample predictive validity testing, to ensure robustness. Additionally, uncertainty intervals are provided to account for variability in input data and modeling assumptions [17].

Case definition

Lower Respiratory Infections (LRIs) were defined as cases of pneumonia or bronchiolitis diagnosed by clinicians based on clinical symptoms, radiographic findings, and/or laboratory tests, following established guidelines. LRIs included diseases coded A48.1, J09-J22, J85.1, P23-P23.9, and U04 in the International Classification of Diseases (ICD) version 10 and 073.0–073.6, 079.82, 466–469, 480–489, 513.0, and 770.0 in ICD version 9. The parameters we used from GBD 2021 are influenza, RSV, Streptococcus pneumoniae, and Hib for etiology. We estimate mortality for both sexes, and for all ages, and under five and above 70 years old from 1990 to 2021, who were diagnosed with LRIs in Saudi Arabia are included in this study. Data were downloaded as number and rate.

Population attributable fractions

LRI etiologies in GBD 2021 were calculated using a newly method, different from previous GBD's studies [16]. To estimate population attributable fractions (PAFs), Multinomial Estimation of Partial and Composite Observations (MEPCO) were used. MEPCO improves upon previous approaches by integrating multiple data sources, including pathogen-specific case-control studies, diagnostic test performance data, and vaccine impact assessments, to more accurately attribute etiologies to LRI mortality. The PAFs represent the relative reduction in LRI mortality if exposure to a particular etiology were eliminated. Due to the documented challenge in the microbiological identification of Streptococcus pneumoniae (pneumococcal pneumonia), the PAFs were derived from a systematic review of literature on PCV vaccine efficacy and effectiveness. Adjustments were made to the overall LRI mortality estimates for 2020 and 2021 to reflect reductions in influenza and RSV mortality due to the COVID-19 pandemic. Moreover, it should be noted that etiologies for neonatal deaths were not attributed due to insufficient quality data. Uncertainty estimates for the PAFs were calculated using 1,000 draws for each parameter based on normal distributions in log space. A detailed description of the GBD 2021 methodology can be found in previous articles[16] and their estimates are available at http://ghdx.healthdata.org/gbd-results-tool.

Risk factors

Among all risk factors in GBD in this paper, we focused on 12 risk factors that are highly associated with LRIs as mentioned elsewhere [2]. In children less than five years old, non-exclusive breastfeeding, childhood stunting, underweight, child wasting, and vitamin A deficiency are the common attributable factors to LRIs. Indoor air pollution, secondhand smoking exposure, lack of access to handwashing facilities, ambient particulate matter, household air pollution, and non-optimal temperature affects all age groups. Smoking prevalence seems to contribute to LRIs in the age group from 15 to + 70 years old [18].

Statistical analysis

This study focused on assessing the main outcome measures related to LRIs, with a particular emphasis on deaths and mortality rates. The deaths are presented in terms of numbers, and age standardized mortality is expressed as the rate per 100,000 people. The GBD estimated 95% uncertainty limits (UIs) for PAFs, and their trends or changes from 1990 to 2019. 95% uncertainty intervals (UIs) were generated for all final estimates as the 2·5th and 97·5th percentiles values of 500 draws (i.e., 500 random samples from the estimate's distribution). Descriptive analyses were conducted on deaths and mortality rates, considering factors such as age group, etiological causes, and year. Change rates between 1990 and 2021 were calculated, and temporal trends were visually represented through plotted graphs. Collected data were entered and analyzed with StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LP.

Results

Mortality burden of LRIs and its trends from 1990 to 2021 in Saudi Arabia

The total deaths attributed to LRIs in Saudi Arabia had decreased to 4032.33 (95% UI: 3209.55,5107.97) in 2021; highest impact of LRIs deaths was 1113.52 deaths (95% UI: 911.69,1359.94) in 2021 in adults aged over 70. In contrast, children under 5 years showed a remarkable 96% decrease in LRI mortality, with dropping from 2089.93 deaths (95% UI: 1574.12, 2948.17) in 1990 to 77.68 deaths (95% UI: 48.7, 109.35) in 2021. The age-standardized mortality rate demonstrated an overall decrease, averaging 47%, from 48.64 deaths per 100,000 (95% UI: 39.54,59.11) in 1990 to 25.69 deaths per 100,000 (21.32, 31.37) in 2021. Remarkably, the decrease in LRI deaths was more significant for children under 5, surpassing the decline in adults over 70 years of age by 51%. (Table 1; Fig. 1)

Table 1 The LRI deaths and mortality in 1990 and 2021, and their Temporal trends from 1990 to 2021 in Saudi Arabia

	Deaths numbers (95% UI)		Percentage change (%)	Deaths per 100,000 people (95%UI)		EAPC: estimated annual percentage change (%)
	1990	2021		1990	2021	
All ages/Age-standardized[1]	4293.26(3460.89,5264.47)	4032.33(3209.55,5107.97)	-6%	48.64(39.54,59.11)	25.69(21.32,31.37)	-47%
Children < 5 years	2089.93(1574.12,2948.17)	77.68(48.7,109.35)	-96%	86.44(65.11,121.94)	3.19(2,4.49)	-96%
Adults 70 + years	959.96(755.44,1202.87)	1113.52(911.69,1359.94)	16%	386.7(304.31,484.55)	214.56(175.67,262.04)	-45%

UI: uncertainty interval

1 Deaths per 100,000 people among all ages were age-standardized mortality in order to comparing the same population over time

The aetiologies of LRIs in Saudi Arabia

Between 1990 and 2021, LRI mortality showed a decline across all four etiologies in Saudi Arabia within all three age groups. In both 1990 and 2021, pneumococcus was the primary cause of LRI deaths across all age groups, contributing to 1471.73 deaths (95% UI: 1172.99, 1847.27) and 664.69 deaths (95% UI: 519.68, 837.7) respectively. Furthermore, RVS-related deaths experienced the most significant decrease over the years, dropping by 90% from 190.43 (95% UI: 146.09, 255) in 1990 to 19.54 (95% UI: 8.41, 37.15) in 2021. Among adults aged 70 and above, pneumococcus emerged as the primary cause of LRI deaths. In 1990, there were 247.22 deaths (95% UI: 194.4, 307.04), and this number decreased to 142.97 deaths (95% UI: 118.15, 173.24) by 2021. Similarly, children under 5 years of age show a decreasing trend across all studied etiologies. Streptococcus pneumoniae demonstrated the most significant decrease, dropping by 99% from 789.42 deaths (95% UI: 584.25, 1133.85) in 1990 to 10.53 deaths (95% UI: 6.49, 14.94) in 2021. Across all years, the age-standardized mortality rate showed a similar trend. The most rapid reduction was evident in RSV-related mortality, which decreased by 90%. Conversely, the slowest decline was seen in Hib-related mortality for adults over 70 years, showing a 59% decrease. (Table 2; Fig. 2)

The LRI mortality attributable to the 12 risk factors in Saudi Arabia

From 1990 to 2021, declining trends were observed in LRI mortality rate attributable to the 12 risk factors studied. The most significant reductions were observed in LRI mortality linked to household air pollution from solid fuels among all the three age groups, achieving a complete 100% decrease in children under 5 years old and 99% in all ages and adult over 70 years old. Moreover, in children under 5 years old, substantial decreases in deaths were linked to child stunting, child underweight, and child wasting, each experiencing a 98% decrease. On the other hand, the slowest declines were observed in low birth weight, which decreased from 104.72 (95% UI) in 1990 to 8.33 (95% UI) in 2021, reflecting a 92% reduction. Furthermore, the death rate for children under five years old attributed to non-exclusive breastfeeding and secondhand smoking was significantly reduced by 96%, from 166.98 (95% UI) to 6.39 (95% UI) and from 217.24 (95% UI) to 8.4 (95% UI) respectively. The risk factor of not having access to handwashing facilities dropped by 99% rapidly in children under 5 (Table A.1, Fig. 3).

During the same period, deaths link to smoking rose significantly by 184% in all ages and by 31% in adult over 70 years of age, although mortality rates dropped by 29% and 38% respectively. Deaths linked to ambient particulate matter pollution increased in adult over 70 by 26%,

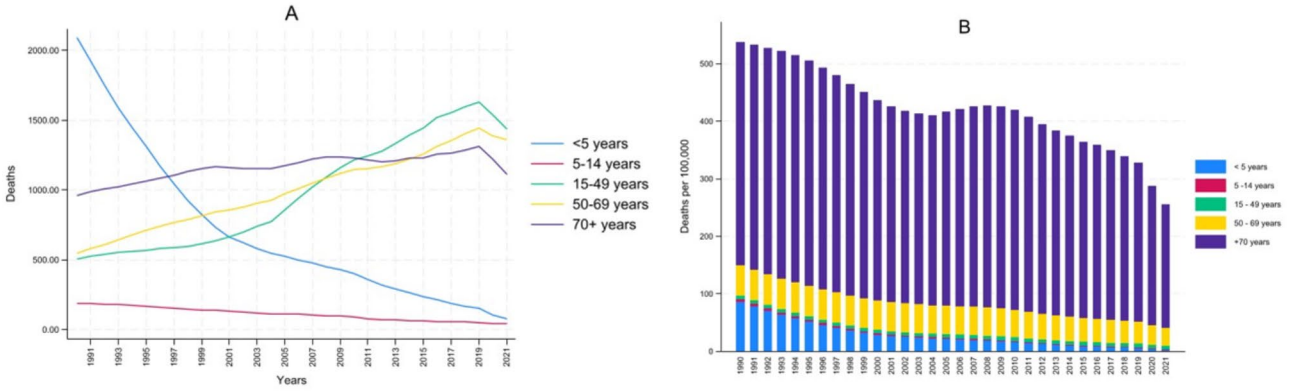

Fig. 1 The LRI deaths and mortality, both sexes, by age group from 1990 to 2021, in Saudi Arabia. (**A**) The annual deaths (number) due to LRIs among different age groups in Saudi Arabia from 1990 to 2021. (**B**) The LRI mortality rate among different age groups in Saudi Arabia from 1990 to 2021

Table 2 The LRI deaths and mortality attributable to the four aetiologies in 1990 and 2021, and trends of LRI mortality from 1990 to 2021 in Saudi Arabia

	Death numbers (95% UI)		Percentage change (%)	Deaths per 100,000 people (95%UI)		EAPC: estimated annual percentage change (%)
	1990	2021		1990	2021	
All ages/Age-standardized[1]						
Haemophilus influenzae	176.02(139.41,223.39)	99.15(78.85,125.29)	-44%	1.64(1.31,2)	0.58(0.49,0.71)	-64%
Influenza	391.94(317.67,479.03)	195.69(84.04,361.36)	-50%	4.94(3.98,6.07)	1.35(0.59,2.63)	-73%
Respiratory syncytial virus	190.43(146.09,255)	19.54(8.41,37.15)	-90%	0.95(0.76,1.22)	0.1(0.04,0.18)	-90%
Streptococcus pneumoniae	1471.73(1172.99,1847.27)	664.69(519.68,837.7)	-55%	14.4(11.72,17.69)	3.6(3.02,4.35)	-75%
Children < 5 years						
Haemophilus influenzae	108.89(79.84,153.24)	2.75(1.71,3.97)	-97%	4.5(3.3,6.34)	0.11(0.07,0.16)	-97%
Influenza	172.83(129.76,243.27)	3.02(1.22,6.07)	-98%	7.15(5.37,10.06)	0.12(0.05,0.25)	-98%
Respiratory syncytial virus	176.11(133.22,240.6)	5.03(2.02,9.85)	-97%	7.28(5.51,9.95)	0.21(0.08,0.4)	-97%
Streptococcus pneumoniae	789.42(584.25,1133.85)	10.53(6.49,14.94)	-99%	32.65(24.17,46.9)	0.43(0.27,0.61)	-99%
Adults 70 + years						
Haemophilus influenzae	26.77(20.63,33.26)	23.18(19.35,27.88)	-13%	10.78(8.31,13.4)	4.47(3.73,5.37)	-59%
Influenza	111.23(87.1,139.54)	63.6(27.65,120.34)	-43%	44.81(35.09,56.21)	12.25(5.33,23.19)	-73%
Respiratory syncytial virus	4.96(3.85,6.23)	2.84(1.25,5.36)	-43%	2(1.55,2.51)	0.55(0.24,1.03)	-73%
Streptococcus pneumoniae	247.22(194.4,307.04)	142.97(118.15,173.24)	-42%	99.58(78.31,123.68)	27.55(22.77,33.38)	-72%

UI: uncertainty interval

1 Deaths per 100,000 people among all ages were age-standardized mortality in order to comparing the same population over time

from 278.84 (95% UI) to 350.04 (95% UI). But the mortality rate per 100,000 people decreased by 40%. Same trend was observed in all ages that death linked to ambient particulate matter pollution was increased by 2% from 1,247.55 (95% UI) in 1990 to 1,266.65 (95% UI) in 2021, but mortality rates dropped by 43%. (Table A.1, Fig. 3).

Among All ages, death and mortality rates linked to child stunting, underweight, and wasting dropped by 98%. In which Child underweight, initially representing 911.12 (95% UI), dramatically decreased to 18.78 (95% UI). Similarly, child stunting and child wasting, which were 648.66 (95% UI) and 640.83 (95% UI) respectively in 1990, demonstrated significant reductions to 11.85 (95% UI) for child stunting and 11.62 (95% UI) for child wasting by 2021. Among adults aged 70 and above, in addition to Smoking and Ambient particulate matter pollution, an increase in LRI death was also linked to High temperature contributed to a 61% increase, from 127.38 (95% UI) to 206.16 (95% UI), and secondhand smoking also increased by 19%, from 69.6 (95% UI) to 82.82 (95% UI). (Table A.1, Fig. 3).

Discussion

Our study provides a comprehensive overview of the fatal burden of LRIs in Saudi Arabia from 1990 to 2021, based on data from the GBD 2021 study. The study reveals

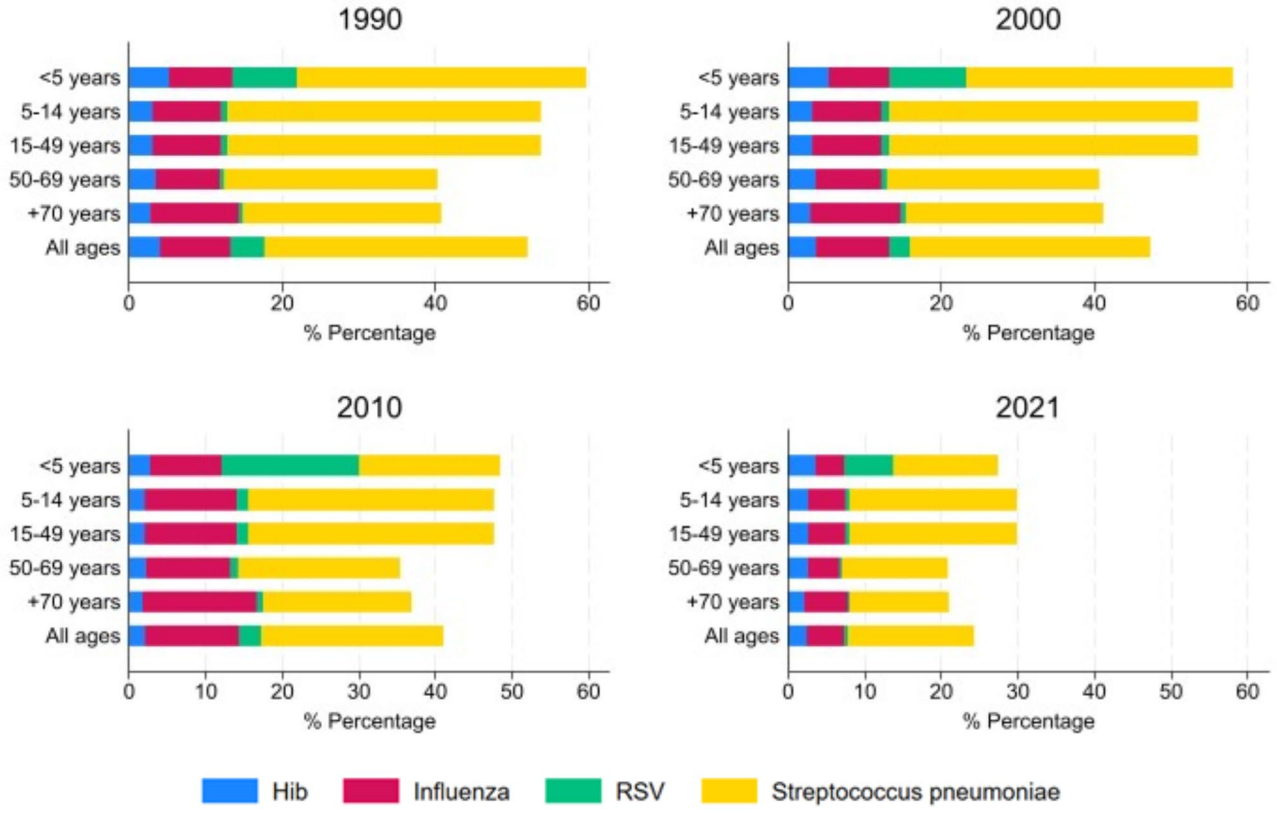

Fig. 2 The aetiologies of LRI deaths, both sexes, by age group, in 1990, 2000, 2010 and 2021, in Saudi Arabia. Haemophilus influenzae type b (Hib) respiratory syncytial virus (RSV)

a significant decrease in the total LRI death rate over the past 30 years, largely due to population growth and demographic shifts. The total LRI death rate decreased by nearly half across all ages, with children under five experiencing a 96% drop. This reduction was faster in children under 5 than in adults over 70 years old. According to Arab Development Portal, Saudi Arabia has experienced a demographic transition over the study period, with a declining proportion of children (ages 0–14) and an increasing elderly population (ages 65+), which has significant implications for disease burden trends. The overall population grew from 16 million in 1990 to 35 million by 2021 [19], with the age group of 60 and above growing faster than other age groups. By 2021, older adults made up about 3% of the total population, reflecting an aging society trend [20]. Factors such as increased life expectancy and declining fertility rates are reshaping the age pyramid [21], leading to a more than doubled number of older adults, emphasizing the importance of addressing the aging population's needs.

Pneumococcus remained the top cause of LRI deaths, but RSV-associated deaths fell by 90%. However, rising mortality from smoking and high temperature in older age groups pose new public health challenges. Despite the significant reduction in LRI-related deaths, particularly among children under five, LRIs continue to pose a substantial fatal burden, especially among the elderly.

The reduction of the LRI mortality rate of children below five years of age has been 96%, from 2,089.93 deaths in 1990 to 77.68 in 2021. This finding is similar to the globally downward trend [22, 23]. Factors contributing to this finding include increased health care availability, expansion of immunization programs and improvements in maternal and childcare [24, 25]. The complete removal of LRI mortality due to indoor pollution from solid fuels reflects the successful implementation of clean energy resources programs and improved households conditions [3]. Our finding is combatable with previous study indicating that reductions in household air pollution from solid fuels contributed to the reduction in the LRI-related deaths in the Middle East and North Africa region beteen 2005–2015. Such developments have been very important because young children are most susceptible to such emissions [25].

Malnutrition is a significant risk factors for LRI disease burden and morbidity in children [26]. Our data showed a significant decrease in the mortality rate associated with malnutrition indicators like stunting, underweight and wasting. Promoting breastfeeding and appropriate

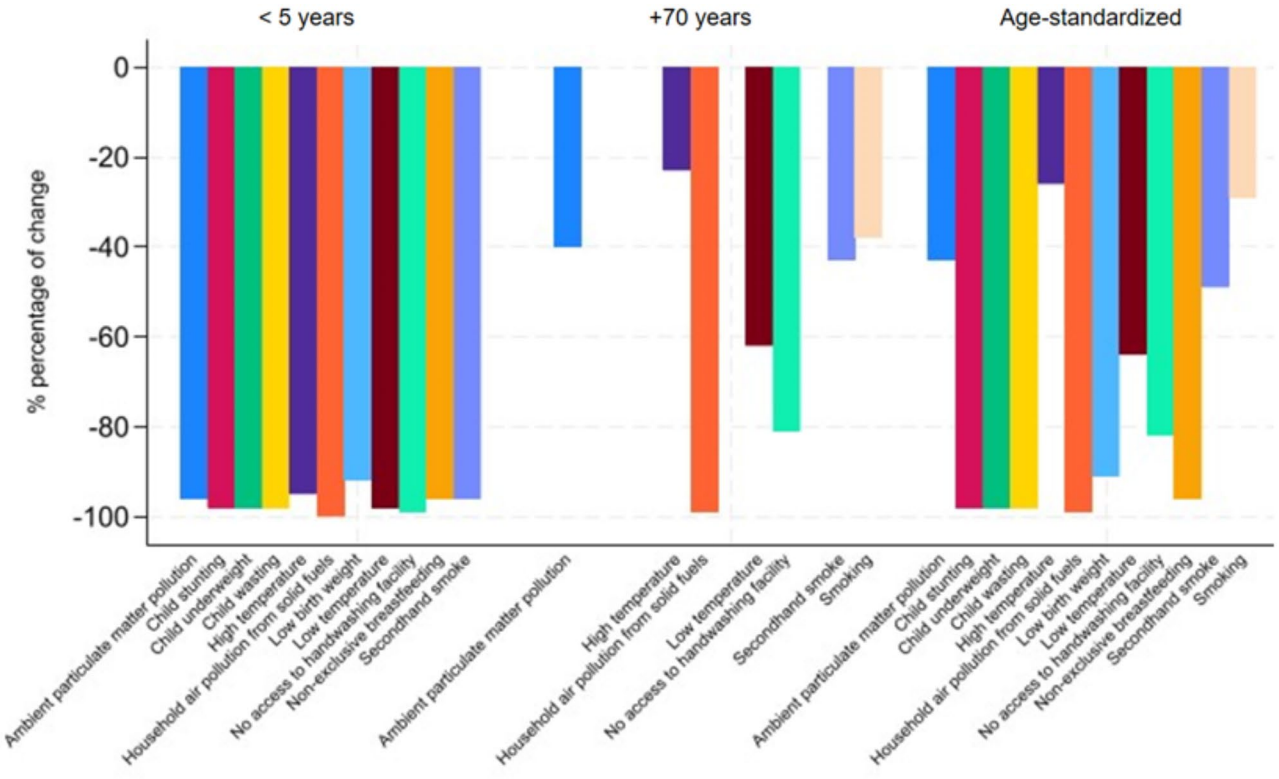

Fig. 3 The percentage of change % of LRI mortality attributable to the 12 risk factors by age group, from 1990 to 2021, in Saudi Arabia

infant feeding practices is crucial in reducing vulnerability to respiratory infections. It was suggested that breastfeeding intervention programs must be initiated before pregnancy to reduce the global burden of LRI through nutritional interventions [27]. Despite the substantial decreases in mortality related to malnutrition, there is limited information on breastfeeding in Saudi Arabia to track progress and establish promotion strategies [28]. The World Health Organization does not include breastfeeding data in the country profile since there is no national breastfeeding data [29,30].

The reduction of the LRI mortality rate of children below five years has been significant, but the persistence of risk factors like low birth weight (-92%), suggests further efforts are needed [31, 32]. The Saudi Ministry of Health has implemented the "Mother Baby-Family Friendly Maternity Care Facility (MBFMF) Initiative," which emphasizes maternal and neonatal health, including education on low birth weight and its associated risks. *Saudi Ministry of Health Publications*. 2020. Available at: https://www.moh.gov.sa. Overall, these results illustrate the ultimate impact of targeted health strategies in enhancing child health outcomes, while also indicating areas for further intervention to ensure sustained progress. In comparison to this, the mortality burden from low respiratory infections among older men and women aged 70 years and above has not improved, with the number of deaths rising by 16% 2021. A similar trend was observed globally [33]. This increase can be attributed to weaker immunity, complications associated with LRIs in the elderly, and aging also affecting treatment response [34].

The COVID-19 pandemic has led to an increase in respiratory disease cases in the last two years. Possibly due to improved diagnostics and reporting. However, the study does not distinguish between COVID-19 and non-COVID-19 cases, as the estimates are based on the GBD 2021 methodology, which accounts for pandemic-related disruptions in healthcare and respiratory disease trends. Pneumococcus remains the most common cause of deaths in people over 70 years old, particularly those suffering from LRI. This is due to the large number of pilgrims attending the pilgrimage, with contamination sources including surfaces in community kitchens such as the tables, drinking sources, and ice supply [35]. The 2019 GBD study revealed pneumonia affected millions globally [2]. Which means that there are still serious health concerns in older adults due to respiratory diseases. This highlighting the need for increased vaccination campaigns, increased health facilities accessibility, and health driven programs for the elderly population. Furthermore, smoking (31%) and high temperature (62%) have led to an increase in deaths in older people, raising concerns about the health and lifestyle of those at environmental

risks. While the overall death rates have been declining, likely due to greater awareness and higher educational standards in regions like Makkah, Riyadh, and the Eastern region [36]. More attention should be given to policies aimed at reducing tobacco use and improving air quality in the other regions.

The analysis of Saudi Arabia's LRI aetiologies from 1990 to 2021 reveals noteworthy mortality associations with these infections. The drop in all four major LRI aetiologies, including pneumococcus and Respiratory Syncytial Virus, highlights progress in public health intervention and medical therapy throughout this time span [37]. Although pneumococcus remains the most important cause of death due to LRI, their general mortality has been decreasing, these data indicate that this pathogen still represents a relevant menace. In a similar manner to our results, Streptococcus pneumoniae was the leading LRI etiology in 2017, also caused the highest number of LRIs in Africa [38]. Therefore, expanding vaccine coverage-for example, pneumococcal conjugate vaccines-could avert a remarkable number of deaths [38]. The pneumococcal vaccine has proven to reduce overall morbidity and mortality in healthy adults and invasive pneumococcal disease [39]. PCV and Hib vaccine were introduced into Saudi Arabia's National Immunization Program in the early 2000s as part of a broader strategy to combat vaccine-preventable diseases and enhance public health measures. The PCV was officially introduced in January 2009 to help prevent invasive pneumococcal diseases, as highlighted by the Saudi Thoracic Society and various health policy reports [40]. Similarly, the Hib vaccine was incorporated into the national immunization program in 2002, reflecting Saudi Arabia's efforts to strengthen pediatric health through vaccination initiatives [41]. In addition, the influenza vaccine has been part of Saudi Arabia's health strategy for many years, with efforts to increase vaccination rates among various population groups. The influenza vaccine is offered free of charge at public health clinics, and the vaccination coverage among healthcare workers has reached 65.1% as of recent data [42]. This is a significant part of the country's efforts to reduce the incidence and severity of influenza-like illnesses [43]. Also, Saudi Arabia has established a vaccination schedule for newborns, contributing to the reduction in mortality rates from listed etiologies [44]. The accessibility of effective vaccines was high, with the recent type of pneumococcal vaccine launched in Saudi Arabia in January 2009 after its licensing in 2000 to prevent invasive pneumococcal disease [45]. Vaccination includes both the pneumococcal and Haemophilus influenza type B vaccines starting at two months old [44]. Additionally, as a mandatory requirement for school, children must be fully vaccinated before six years old [46]. Thus, parent commitment to children's vaccination is high in Saudi Arabia, despite a small portion of resistance [47].

In summary, Saudi Arabia, has seen a significant decline in LRI mortality for children ubder five years old, largely due to public health interventions and preventive measures. However, high mortality burdens among older adults and increased risk factors require constant adaptation of health strategies. Future initiatives should focus on improving environmental health, vaccination programs, and ensuring equity in healthcare and nutrition. By addressing past successes and emerging challenges, Saudi Arabia can continue to reduce respiratory disease burdens while improving health outcomes for all its citizens.

Limitations

This study has serval limitations, first, the study relies on data from the GBD 2021 study, which may have limitations in data quality and completeness, particularly for specific regions within Saudi Arabia. Second, it is important to acknowledge that our findings are derived from population-level data, which may introduce an ecological fallacy bias. This means that patterns observed at the population level may not necessarily apply to individuals within that population. Additionally, the study may not account for all potential confounding factors, such as socio-economic status, healthcare access variations, and lifestyle differences, which could influence LRI mortality trends.

Conclusion

This study highlights significant progress in reducing LRI mortality in Saudi Arabia over the past three decades, particularly among children under five, due to improvements in healthcare services and vaccination programs. However, the persistent high mortality rates among the elderly underscore the need for targeted interventions to address their unique vulnerabilities. Our findings emphasize the importance of continued investment in public health infrastructure, enhanced vaccination coverage, and strengthened environmental health initiatives to further reduce the burden of LRIs. Addressing these challenges while building on the successes of existing programs will be essential for Saudi Arabia to sustain progress in reducing respiratory infections disease burdens and improving overall population health outcomes.

Abbreviations

LRIs	lower respiratory tract infection
RSV	Respiratory syncytial virus
Hib	Haemophilus influenzae type b
GBD	Global burden of disease
CODEm	Cause of death ensemble model
ICD	International classification of diseases
PAFs	Population attributable fractions
UIs	Uncertainty limits

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-025-00882-7.

Supplementary Material 1

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Author contributions
Study conception and design: R.M and R.A. Data extraction and analysis: B.R. Manuscript writing: B.R, A.J, Y.H, R.M, and R.A. Supervision and revision of the manuscript: R.M and R.A. All authors contributed to the data interpretation and review, editing, and manuscript revisions.

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Data availability
We used Global Burden of Disease Study 2021 (GBD 2021) Data Resources, a public use data available through Global Burden of Disease Study 2021 (GBD 2021) Data Resources| GHDx.

Declarations

Ethics approval and consent to participate
N/A.

Consent for publication
N/A.

Competing interests
The authors declare no competing interests.

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