The influence of disparities on intensive care outcomes in children with respiratory diseases: a systematic review

Tahira Hussain[1], Sarah van den Berg[1], Kirsten Ziesemer[2], Dick Markhorst[1], Susanne Vijverberg[3], and Berber Kapitein[1]

[1]Emma Childrens' Hospital UMC
[2]Medical Library, Vrije Universiteit Amsterdam
[3]Amsterdam UMC

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Abstract

Context – The negative effects of socioeconomic, environmental and ethnic inequalities on childhood respiratory diseases are known in the development of persistent asthma and can result in adverse outcomes. However, little is known about the effects of these disparities on pediatric intensive care unit (PICU) outcomes in respiratory diseases. Objective – The purpose of this systematic review is to evaluate the literature on disparities in socioeconomic, environmental and ethnic determinants on PICU outcomes. We hypothesize that these disparities negatively influence the outcomes of children's respiratory diseases at the PICU. Methods – A literature search (in PubMed, Embase.com and Web of Science Core Collection) was performed up to September 30, 2022. Two authors extracted the data and independently evaluated the risk of bias with appropriate assessment methods. Articles were included if the patients were below 18 years of age (excluding neonatal intensive care unit admissions), they concerned respiratory diseases and incorporated socioeconomic, ethnic or environmental disparities. Results – Of 8746 references reviewed, 15 articles were included; seven articles on the effect of socioeconomic status, five articles on ethnicity, one on the effect of sex and lastly two on environmental factors. All articles but one showed an unfavorable outcome at the PICU. Conclusion – Disparities in socioeconomic (such as a low-income household, public health insurance), ethnic and environmental factors (such as exposure to tobacco smoke and diet) have been assessed as risk factors for the severity of children's respiratory diseases and can negatively influence the outcomes of these children at the PICU.

Introduction

At the end of 2021, it was estimated that more than 24% of children in Eastern Europe and Asia live in poverty due the effects of the COVID-19 pandemic, climate change, high inflation, the energy crisis and numerous humanitarian crises, and these numbers further increased in 2022 due to the war in Ukraine[1,2]. Although often overlooked, poverty has a large impact on a child's (respiratory) health. Living in poverty influences all social determinants of health (SDH), which can be divided into material, psychosocial, behavioral and structural determinants[3]. Material SDH might be the most visible and may have a direct impact on a child's health, which was also seen after the recession of 2008-2013[4]. Increased prices of food lead to poorer nutritional status whereas the energy crisis leads to cold houses. Children in cold houses are at increased risk of asthma attacks and respiratory infections. This is not only caused by overcrowded houses when people stay indoors, but also by poor ventilation, formation of mold and growth of house dust mite[5]. An indirect effect of poverty can be seen in parents who experience financial strain, who are less likely to quit smoking and more likely to relapse[6]. Furthermore, economic recession and unemployment induces a higher probability for smoking by these parents, leading to increased exposure to possible triggers for children with asthma living under those circumstances[7,8]. Gaffney et al. found that over the past four decades asthma prevalence increased among children but rose more sharply in children with parents in a lower income

group[9]. Additionally, structural SDH may influence health as well, and is defined as socioeconomic, political, cultural and commercial structures that for instance influence accessibility of resources and services across the population such as pediatric health services, childcare, schools, welfare systems but also food marketing.

The effect of socioeconomic circumstances (SEC) on childhood respiratory diseases are especially clear in the development of persistent asthma. In the UK, disadvantages in early-life are associated with a 70% greater risk of persistent asthma in adolescents, with almost two-thirds of the excess risk being explained by both perinatal and environmental mediators, with home environment being more important than more distal exposures outside the home[10]. Also, early-life risk factors such as maternal smoking during pregnancy and lower rates of breastfeeding in disadvantaged groups have been shown to be mediators for persistence of wheezing[11]. Similar findings are reported in Australia and the USA[12]. In a study done in the USA by Case et al, it was found that disadvantaged children with asthma were more likely to have severe asthma compared to more advantaged children[13]. In another study examining risk factors for life threatening asthma in the USA in minority inner city children, there was a high rate of previous pediatric intensive care (PICU) admissions and growing up in an extremely poor household even doubled the risk for a PICU admission for severe acute asthma[14]. Interestingly, in the whole study population, only 27.4% of the children previously admitted to a PICU for asthma had been seen by an asthma specialist[14]. Another important finding in this study group was that 30.5% of the caregivers had symptoms of depression and 56.4% of the caregivers perceived their child's asthma as well controlled[14]. Accessibility to a health care system, part of structural SDH, seems to be even more important for this vulnerable minority group.

Similar to asthma, it may be expected that healthcare inequities (HI) also exist for other respiratory diseases at the PICU. Several studies have shown that children from families with a lower income are not only more likely to be admitted to a PICU but are also more severely ill and more likely to die before discharge[15-18]. This inequality transcends patient-level, since it has been shown that PICU use and PICU length of stay (LOS) is higher when coming from a neighborhood with higher poverty rates compared to neighborhoods with low poverty rates[19]. It has been suggested that these higher-poverty neighborhoods have less accessibility to the health care system, poor living conditions and a distressed social environment. Indeed, Brown et al showed that in the USA, the physical distance to a PICU increases with poverty[20]. Besides the psychological effects on a child and its caregivers after a PICU admission, medical (in the case of uninsured patients) but also non-medical costs (transportation, meals) and the necessity to take leave of absence from their jobs can give a huge strain on already financially distressed families[21,22]. Both the risk of a post-PICU syndrome as well as the financial effects increase with a longer PICU LOS. To our knowledge, only scarce data are available on effects of socioeconomic, environmental and ethnic factors on PICU outcomes in childhood respiratory diseases. Our hypothesis is that disparities in these factors also negatively influence the outcomes of children's respiratory diseases treated at the PICU.

Materials and Methods

Statement – This systematic review of the literature was conducted in the department of the pediatric intensive care at the Emma Children's Hospital in Amsterdam. The conduct and reporting of this review adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-statement[23].

Search – After several scoping searches, three bibliographic databases (PubMed, Embase.com and Clarivate Analytics/Web of Science Core Collection) were searched for relevant literature from inception to September 30th, 2022. Searches were devised in collaboration with a medical information specialist (KAZ). Search terms (including synonyms), closely related words and keywords were used as index terms or free-text words, which were "pediatric intensive care unit" and "inequalities". The searches contained no date or language restrictions that would limit results. The references of the included full-text studies and relevant systematic reviews were searched for additional relevant literature. Duplicate articles were excluded using the R-package "ASYSD" an automated deduplication tool[24], followed by manual deduplication in Endnote (X20.0.3) by the medical information specialist (KAZ). The full search strategy used for each database is detailed in appendix A in the supplementary material. Studies were included if they met the following criteria: patients under the age of 18 years old (excluding premature infants), admission to the PICU with a primary diagnosis based

on a respiratory disease, results available on outcome (defined by mortality, PICU LOS and resource use at the PICU (e.g. support of a ventilator)) and studies reviewing health care disparities by socioeconomic factors, insurance status, ethnicity, environmental factors or gender. Exposure to environmental tobacco smoke (ETS) and bad nutritional status can be seen as an indirect effect of economic recession and poverty, therefore we decided to search for articles with smoking and diet as risk factors as well. In addition, studies were excluded if they were of the following publication types: editorials, letters, legal cases or interviews.

Selection process – Two reviewers (TH and BK) independently screened all potentially relevant titles and abstracts for eligibility using the Rayyan software[25]. If necessary, the full text article was checked for the eligibility criteria. Differences in judgement were resolved through a consensus procedure.

Data assessment – The full text of the selected articles was obtained for further review. Two reviewers (TH and BK) independently evaluated the methodological quality of the full text papers using the critical appraisal skills programme (CASP) checklist[26].

Results

The literature search generated a total of 21903 references: 6398 in PubMed, 9523 (5522 excluding conference abstracts) in Embase.com and 5982 in Clarivate Analytics/ Web of Science Core Collection. After removing duplicates of references that were selected from more than one database, 8746 references remained. Finally, 15 articles were included in this systematic review. The summary of the included articles is presented in Table 1. A flow chart of the search and selection process is presented in Figure 1 (included in Appendix A in the supplementary material).

Socioeconomic status

Several studies have identified an association between socioeconomic status and outcome of respiratory diseases at the PICU. Mukherjee et al. studied the characteristics of children admitted at the PICU for asthma. They found that children from deprived neighborhoods comprised most of the PICU admissions (61%); moreover, these children also had the highest proportion of deaths and received mechanical ventilation most frequently[27]. However, they surprisingly reported an increase in the Pediatric Index of Mortality score (PIM2)-score for children that lived in lesser deprived areas, also after adjusting for age, sex and the year[27]. Another study on acute respiratory failure in England and Wales also reported a higher proportion of admitted infants coming from deprived areas[28]. Interestingly, Swathi et al. found that all of the children that died in their study (5,9%) were born with a lower socioeconomic status (defined by the Kuppuswamy scale, which is a composite score of education and occupation of the head of the family, along with the monthly income of the family)[29].

Another study also reported an independent association between socioeconomic stratum (defined by income, employment, housing and educational level) with the development of severe RSV disease and respiratory failure in infants[30]. This study confirmed the findings by Slain et al, who found that children with severe bronchiolitis coming from a low-income household, had a longer LOS at the PICU and an increased need for mechanical ventilation compared to children raised above poverty threshold[31]. Finally, another study found that having a lower median household income decreased readmission intervals for asthma, after being admitted to the PICU for severe acute asthma before[32]. The studies above show that there are unfavorable outcomes in patients admitted at the PICU with respiratory problems having a lower socioeconomic status. In conclusion, in acute pediatric respiratory diseases, outcomes such as mortality, LOS, mechanical ventilation and readmission interval are negatively correlated with poverty and being a minority living in a deprived area.

Insurance status

Bratton et al. describe an association between the outcomes of patients admitted to the PICU and their insurance status[33]. The primary goal of this retrospective cohort, including the data of fourteen PICU's, was to determine whether there was an association between insurance status and PICU LOS, as well as the length of mechanical ventilation in children admitted with asthma. They found that children admitted with

severe asthma with a public health insurance were significantly more likely to not only receive mechanical ventilation, but also had longer use of mechanical ventilation, and a longer LOS compared to the children with the same illness severity yet insured by commercial or Health Maintenance Organization (HMO) insurance[33]. Also, Epstein et al. reported an association between having government insurance, as opposed to indemnity insurance, and a higher PIM2-score at admission in children with respiratory diseases at the PICU[16]. Finally, Silber et al. evaluated the effect of both insurance status and ethnicity on outcome[34]. In this multivariate, matched cohort study across thirty-three states that, among other things, compared the outcome between white and black children who were admitted to the hospital with asthma and had a Medicaid (public health) insurance, it was found that race did not influence re-admissions or deaths. However, they did find a small but significant difference in PICU use and the LOS at the PICU in black children[34].

Ethnicity

Several other studies also explored the association between ethnicity and PICU outcomes. Firstly, one article included children with a status asthmaticus admitted to the PICU, where a distinction was made between children with or without respiratory failure[35]. They found that African American children were significantly more likely to be intubated compared to the children of other races and ethnicities. No associations were found between respiratory failure and sex, age, or obesity[35]. Hardelid et al. included children with an influenza infection in England and showed a higher mortality rate in children from Asian, Asian-British and other non-majority ethnic groups compared to white British children[36]. Additionally, O'Donnell et al. showed that respiratory failure and overall mortality due to respiratory failure at the PICU was significantly higher in South Asian infants compared to other ethnicities[28]. On the other hand, one study which also included children with asthma admitted to the PICU described that African Americans had a higher than expected rate for admissions, however no racial or ethnic disparities in the outcomes, which included mechanical ventilation, were found[37]. Finally, Epstein et al. explored whether being a minority in a big city, in this case being Latino, had an effect on the severity of respiratory diseases at the PICU[16]. They found that having a Latino ethnicity and living in a neighborhood with predominantly other Latinos were both associated with a higher initial severity of illness at the PICU but did not have an effect on the mortality rates[16].

Environmental factors

ETS – Samir et al. looked at the impact of ETS on outcomes in children at a PICU with severe acute asthma[38]. In this retrospective study, they found that children who were ETS-exposed had a significantly longer overall LOS at the PICU of 15% compared to children who were not exposed to ETS; moreover, these children deteriorated faster between the emergency department and the PICU. No differences were found in number of patients who received mechanical ventilation[38].

Diet – In an attempt to evaluate the effect of zip code (coming from an area with lower median income) and diet on the PICU outcomes in infants with bronchiolitis, Leimanis Laurens et al. performed a retrospective chart review of infants (0-5 months of age) admitted to the PICU with a primary or secondary respiratory diagnosis, in which they divided the patients in formula fed, breastmilk fed or a mixed diet[39]. They found that significantly more infants from a lower household income were formula fed and had a public insurance. However, in the clinical outcomes, no differences were found in PICU LOS, overall LOS, mortality or the need for extra corporeal membrane oxygenation (ECMO)[39]. Swathi et al, described infants admitted with an acute respiratory infection and the association between infants who were exclusive breast fed until the age of six months old, and infants who were not, and found a significantly higher mortality rate of the infants in the latter group[29].

Sex

Frigyesi et al., conducted a prospective observational study comparing the standardized mortality rate (determined by an estimated and observed mortality rate within 90 days after admission to the PICU) between male and female pediatric patients admitted with respiratory insufficiency. They found a significantly higher mortality rate in females[40]. There was no difference in outcome concerning the PICU LOS[40].

Discussion

Disparities in socioeconomic status

In this review we describe the influence of socioeconomic, environmental and ethnic disparities on PICU outcomes in childhood respiratory diseases. Children from families living in poverty or being minorities not only comprise a higher proportion of PICU admissions for respiratory diseases[27,28], but there is an association with higher mortality rates as well[29]. A few possible proposed explanations for the higher prevalence of respiratory diseases and the higher proportion of deaths in this group are psychosocial processes, such as parental stress, overcrowding, illiteracy and malnutrition[27,29]. Socioeconomic inequalities tend to have an effect on the morbidity at the PICU as well: children from deprived neighborhoods have a higher severity of illness, a larger chance on respiratory failure and were mechanically ventilated more frequently[16,27,30]. Usually, being a minority and living in a neighborhood with other minorities tends to be protective, but these studies state otherwise, even after correcting for factors such as ethnicity, income and insurance[16]. This finding of increased morbidity may be explained by low acculturation and health illiteracy (e.g. parents or child only skilled in speaking native language in an English-speaking country, or lessened understanding of the health care system), which could in turn lead to decreased knowledge about medical care options[16]. Moreover, a low collective social capital could lead to neighborhoods where neighbors are not able to help each other and result in further impoverishment[16]. Finally, socioeconomic status may lead to a more severe disease course because of a lower parental education level, more exposure to indoor smoking, a limited access to healthcare, suboptimal medical care during emergencies, and structural problems in public health care services[30]. Previous studies describing the connection between poverty and outcomes in critically ill children derived these effects to limited knowledge about preventive primary care and an unhealthy lifestyle[31]. With the increasing food prices, the choice for unhealthier and often cheaper food is easily made.

Disparities in insurance status

Studies focusing specifically on respiratory diseases and outcomes at the PICU based on the type of insurance status are scarce. Lopez et al. performed a large multicenter study of critically ill patients admitted at the PICU and found no differences in outcome (assessing mortality rates and overall resource use) regarding to sex, race and insurance status, after adjusting for illness severity[15]. One of the limitations of this study was the underrepresentation of ethnic minorities. Nevertheless, they did demonstrate that uninsured children had the highest rate of mechanical ventilation[15]. This data is supported by the findings in this review where Bratton et al. showed an increased use of mechanical ventilation in children with a public health insurance[33]. However, they also demonstrated a longer length of stay at the PICU in children admitted with asthma[33]. In addition, Silber et al. described a prolonged PICU LOS in patients admitted with asthma with a public health insurance[34]. These reported outcomes are possibly related with the use, quality and availability of primary health care[15,33].

Disparities in ethnicity

The association between ethnicity and outcomes in children has been previously described in the literature, with conflicting outcomes. Although few studies demonstrate no correlation between race or ethnicity and outcomes at the PICU[15,41], the majority shows the opposite. In addition, previous studies conducted in the United States and United Kingdom have also shown a higher risk of mortality in critically ill pediatric patients from several ethnic groups (especially Asian) admitted to the PICU[36,42]. In this review three studies were described on the association between race or ethnicity and pediatric outcomes in childhood respiratory diseases. It was found that African American children with asthma were significant more likely to be admitted and intubated[35,37], Asian/ Asian British children with an influenza infection had a higher chance of mortality[36], and South Asian babies with a respiratory failure had a significantly higher rate of mortality[28]. These conflicting results may be explained by the fact that the minorities were underrepresented, and the data entry of ethnicity was not always complete[15,41].

Disparities in environmental factors

ETS – Previous studies have associated ETS with severe asthma and a decrease in the lung function of children with asthma[42,43], however no studies evaluating the effect on outcome of these admitted children were conducted. Samir et al. did perform a retrospective study and showed a significant negative effect on LOS at the PICU of children admitted with a status asthmaticus who were ETS exposed and thus found an adverse outcome[38]. However, information on ETS exposure in this study was retrieved by parental information, which could implicate information bias.

Diet – Breastmilk has been associated with a positive effect on outcomes in pediatric health. Multiple studies have been performed that show a positive effect of breastmilk in the health of children with some respiratory diseases, that could be explained by the immunobiological components in breastmilk that can increase protection from respiratory diseases[44,45]. Additionally, Swathi et al, found a lesser mortality rate in infants with acute respiratory infection (ARI) admitted at the PICU that were exclusively breastfed in the first six months, but did not specify the causes of the ARI[29]. However, Leimanis Laurens et al. is the first study to find a contrary result and did not find any association between the diet and outcomes in infants admitted with a bronchiolitis at the PICU[39], but had their data retrieved from a single study site; there was limited information about the quantities of the milk given and there was a difference of age between both groups.

Disparities in sex

In many studies, the sex of the patients is included when describing the demographics. However, not many studies are designed and conducted specifically on the association between sex and outcomes in pediatric respiratory diseases. Frigyesi et al. showed a higher female mortality ratio in patients admitted with respiratory failure at the PICU but no difference was found in received care between the groups, and thus no explanation was found on the observed differences in outcomes related to the patient's sex[40]. However, no distinction was made between the different etiologies of the respiratory insufficiency[40]. Further research is needed to identify if there truly is a sex difference related to outcomes in this patient group, and the underlying causes if so.

Limitations

This review has a few limitations regarding the material and methods and available evidence. First of all, there was a high heterogeneity between the included studies in terms of population, type of disease, which inequality was being addressed and outcome, making it difficult to group these studies and draw definite conclusions. Moreover, because various outcome measures were used it was not always possible to obtain objective or numerical results and therefore subjective interpretation may have taken place. Finally, bias might have occurred due to the publication of studies which showed an effect of socioeconomic, ethnic or environmental inequalities on PICU outcome.

Implications for the future

This review demonstrates that inequalities in children with respiratory diseases at the PICU exist and may have a considerable effect on their morbidity and even mortality when admitted. To our knowledge, this is the first review addressing these inequalities in this specific patient group. In the future, it is important that health care professionals are aware of these disparities when treating patients from certain groups; however, it is impossible to overcome these effects as a doctor. It stresses the importance for governmental instances to address these disparities and work towards equal opportunities for all. More research is needed to truly evaluate the effect of socioeconomic, ethnic and environmental effects on the PICU outcome of children with respiratory diseases, and to find out the explanations for these possible associations.

Conclusion

Disparities in socioeconomic factors, ethnicity, sex, and environmental factors can be considered to be risk factors for the severity of child respiratory diseases and negatively influence the outcomes of these children admitted and treated at the PICU. With increasing child-poverty numbers and the current recession, we

should be looking more closely into these vulnerable patient groups and look for measures on how to prevent these detrimental effects.

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Author (year)

Study design

Number of patients

Age

Patient population

Study variables

(socio-economic status, insurance type, ethnicity, environment, sex)

Primary and secondary outcome variables

Bratton et al., (2002)

Retrospective cohort study

1333

<18 years

Children with a primary diagnosis of asthma admitted to one of 14 PICU's in the U.S.A.

Insurance type (commercial, health maintenance organization, Medicaid, self-pay or 'other')

PICU LOS, hospital LOS, duration of mechanical ventilation, PRISM-III score

Epstein et al., (2014)

Retrospective observational study

5390

1-12 years

Children with a primary respiratory diagnosis admitted to the PICU in the U.S.A.

Ethnicity, neighborhood's ethnicity and median income, insurance type

PIM2-score, mortality

Files et al., (2009)

Retrospective chart review

125

<18 years

Children with asthma admitted to the PICU in the U.S.A.

Ethnicity

Need for PICU admission, mechanical ventilation

Frigyesi et al., (2017)

Prospective observational study

21972

<18 years

Children with a respiratory insufficiency admitted to the PICU in Sweden

Sex

PICU LOS, mortality

Hardelid et al., (2018)

Retrospective data analysis

1961

< 16 years

Children with an influenza infection admitted to the PICU in England

Ethnicity, socio-economic status

Mortality, type of ventilation

Jroundi et al., (2019)

Retrospective cohort study

13501

2-17 years

Children from four states in the U.S.A. hospitalized for asthma with a prior asthma-related admission to a PICU

Ethnicity, median household income for the state, type of medical insurance

Asthma-related readmission

Leimanis Laurens et al., (2020)

Retrospective chart review

187

<5 months

Infants admitted to the PICU in the U.S.A. with a severe respiratory illness

Diet (breastfed, formula fed), insurance status, median household income (from zip code)

PICU LOS, readmission, mortality

Mukherjee et al., (2022)

Prospective observational study

2195

<14 years

Children with asthma admitted to the PICU in England

Socio-economic status (English Index of Multiple Deprivations categorized in domains of income, employment, health, education, housing, crime and living environment)

PIM2-score, mechanical ventilation, PICU LOS, survival

O'Donnell et al., (2010)

Prospective observational study

4641

<1 year

Infants with an acute respiratory failure admitted to the PICU in England or Wales

Ethnicity

Mortality

Rodriguez-Martinez et al., (2022)

Cross-sectional cohort study

1215

<5 years

Children with an infection with RSV admitted to the PICU in Colombia

Ethnicity, socioeconomic stratum (high, middle and low based on socioeconomic factors, such as income, employment, housing, and education), type of health insurance coverage

Respiratory failure (need for (non)-invasive ventilatory support), need for PICU admission, mortality

Sala et al., (2011)

Retrospective data analysis

3318

<18 years

Children with asthma admitted to the PICU with respiratory failure in the U.S.A.

Ethnicity

PICU LOS, PIM2-score, PRISM-III score, respiratory failure (mechanical ventilation)

Samir et al., (2011)

Retrospective study

230

2-11 years

Children with asthma admitted to a PICU in Canada

ETS

PICU LOS, clinical asthma score

Silber et al., (2017)

Multivariate matched cohort design

11079

3-18 years

Children with asthma admitted to the PICU in the U.S.A.

Ethnicity, medical insurance type

PICU LOS, need for PICU admission

Slain et al., (2018)

Single-center retrospective study

145

2-11 months

Infants with a bronchiolitis admitted to the PICU in the U.S.A.

Median household income, ethnicity

PICU LOS, hospital LOS, PIM2-score, mechanical ventilation

Swathi et al., (2021)

Prospective observational study

2793

2 months-5 years

Children and infants with an acute respiratory disease admitted to the PICU in India

Breastfeeding practices (diet), socioeconomic class as per modified Kuppuswamy scale

Hospital LOS, need for PICU admission, mechanical ventilation, mortality

Table 1 : Methodological characteristics of all included studies.

Abbreviations: PICU = pediatric intensive care unit, LOS = length of stay, PIM2 = pediatric index of mortality 2, PRISM-III = pediatric risk of mortality 3, RSV = respiratory syncytial virus, ETS = environmental tobacco smoke, U.S.A. = United States of America

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`Table 1.docx` available at https://authorea.com/users/576309/articles/619263-the-influence-of-disparities-on-intensive-care-outcomes-in-children-with-respiratory-diseases-a-systematic-review