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Prevalence and Clinical Predictors of Severe Pneumonia among School-Aged Children: A Systematized Review

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Abstract

This study aims to explore proof of the occurrence and clinical predictors of pneumonia among school-aged children. A systematic review was conducted, where studies published between the years, 2013 to 2020 were included based on the inclusion and exclusion criteria. The search strategy included free-text terms such as the title and research purpose. However, upon filtration and exclusion of studies based on different reasons, 17 studies were finally selected. Despite the various pathogenesis of pneumonia, findings indicated that environmental conditions contribute significantly to pneumonia, especially when there is poor sanitization and indoor moisture. Studies show that the disease disproportionately affects children from low-income households and regions. Due to the economic status of most of these children, antibiotics are the most prevalent medication administered. This has raised tremendous worry about the risk of developing resistant strains.

Keywords: pneumonia, chronic illness, mortality, review, antibiotics.

1. Introduction

Pneumonia refers to an acute inflammation of the parenchymal structure of the lungs (Beletew et al., 2020). Even though there are several definitions for this kind of disease, all definitions revolve around the idea of inflammation of the parenchymal structure of the lungs (Kalil et al., 2016; Markos et al., 2019). There are many classifications of pneumonia; hospital-acquired pneumonia or community-acquired; the causative mechanisms or agents such as ventilator-associated, fungal, aspiration, or bacterial pneumonia. (Zhang et al., 2016; Cunha & Brusch, 2018; Popovsky& Florin, 2020).

From various studies, it is clear that pneumonia is the leading cause of mortality in children, being responsible for almost one and a half million deaths annually (Mackenzie, 2016; Andualem et al., 2020; Walker et al., 2013). A study showed that pneumonia in Ethiopia is considered one of the significant causes of morbidity and mortality among children below five years old (Wardlaw et al., 2014). Another study by Nirmolia et al. (2017) demonstrated that approximately 16.34% children of under five years suffer from pneumonia in India. Gothankar et al. (2018) highlighted that the World Health Organization estimated the incidence rate of around 0.3 episodes per child yearly. Various expected risk factors are mentioned in the studies that will be reviewed, including low birth weight, measles vaccination lacking, under-nutrition, indoor air pollution, lack of or exclusion of breastfeeding (especially for the younger children), and overcrowding. These can be categorized as clinical predictors that are likely, definite, and possibly based on the available evidence on their association with pneumonia (Rudan et al., 2013). Various other significant factors, as mentioned in some of the studies, contains low socio-economic status, poor hygiene practices regarding breastfeeding and hand hygiene, cockroach infestation, low education level of mothers, low level of knowledge concerning symptoms of pneumonia among mothers, partial immunization of new furniture and absence of a window in the kitchen, lack of a separate kitchen (Gothankar et al., 2018; Abuka, 2017; Gritly et al., 2018; Jiang et al., 2018; Norback et al., 2018).

Studies have suggested the prompt detection and classification of the disease according to the guidelines developed by the World Health Organization is one of the few ways to control and manage the spread of the disease (Agweyu et al., 2014). Therefore it is essential to look at the incidences and risk factors related to the condition among school-age children. Consequently, it is vital to investigate the incidences, prevalence, and risk factors related to the conditions among school-age children. This study aims to explore proof of the occurrence and

clinical predictors of pneumonia among school-aged children. They do so, the study articulates four objectives as follows:

i. To critically estimate proof of the prevalence and incidences of pneumonia among school-aged children

ii. To critically analyze the clinical predictors of pneumonia among school-aged children

iii. To critically evaluate evidence on the pathophysiology, types, and effects of pneumonia in the modern clinical setting

iv. To establish the clinical significance of the diagnosis and management of pneumonia among school-aged children

According to Tawfik et al. (2019), the research topic should be relevant, ethical, novel, interesting, and clear. Therefore, the general research question should have a clear, well-defined, and logical stature. In most quantitative evidence synthesis, the PICO (Population, Intervention, Comparison, and Outcome) framework helps formulate the research question with the above characteristics. According to Methley et al. (2014), this framework is more sensitive in a quantitative evidence study compared to other specific approaches. The table below summarizes the use of the PICO framework in coming up with the research question.

Table 1. PICO framework in the development of the research question

P	School-aged children
I	Severe pneumonia
C	Other pneumonia
O	Risk factors

Developing the most appropriate research questions increases the chances of developing a successful research project (Ratan et al., 2019). Therefore, the following questions will be answered.

a) What are the incidence and prevalence rates of severe pneumonia among school-aged children?

b) What risk factors or clinical predictors are associated with severe pneumonia among school-aged children?

c) What are the different categories and the pathophysiology associated with severe pneumonia in a clinical setting?

2. Method

2.1 Search Strategy

The literature search is one of the foundational steps of a systematic review. Successful research occurs in two stages: the preliminary search and the use of an appropriate search strategy. To ensure the validity of the proposed research topic, it is necessary to conduct a preliminary search (Tawfik et al., 2019). The researcher builds a basic search strategy based on formulating the research topic (PICO framework). The researcher generated key terms used as a search strategy in the systematic review. These key terms include school-aged children AND severe pneumonia OR Children OR Pneumonia, OR risk factors, AND clinical predictors, Causes of pneumonia, OR Pneumonia and Death among Children. The key terms generated have been summarized in the table below:

Table 2. Summary of the generation of keywords using the PICO Framework

P	School-aged children or student children
I	Severe pneumonia
C	Other pneumonia
O	Risk factors or clinical predictors or factors associated with severe pneumonia

2.2 The Inclusion and Exclusion Criteria

The study focuses on the prevalence and risk factors associated with severe pneumonia among school-aged children. Foundationally, the literature included in the study had to be relevant to the topic identified. Relevance is, therefore, a significant element in selecting the articles to be used in the research.

Articles published in full and from 2013 to July 2020 were included in this study. This is because the most recent articles contain the most applicable and appropriate information on the subject matter. This criterion also ensures the inclusion of reliable, valid, and credible articles. The summary of the inclusion and exclusion criteria has been shown below.

Table 3. Summary of the inclusion and exclusion criteria used in the identification of articles used for the review

Inclusion	Exclusion
Literature relevant to severe pneumonia among school-aged children	Literature focusing on severe pneumonia among adults
Full-text publications	Abstract only articles
Peer-reviewed articles, journals, or publications	Non- peer-reviewed articles and unpublished literature
Publications in the English language	Publications in other languages
Journals published from 2013- 2020	Publications before 2013

2.3 Critical Appraisal

In the research process, it is essential to guide the facilitation and evaluation of the research articles that the researcher identifies (Aveyard, 2010). This research uses the CASP tool in the critical appraisal, similar to most clinical research. The Critical Appraisal Skills Programme (CASP) tool is effective in the specific and versatile evaluation of evidence in terms of credibility, reliability, and validity.

2.4 Search Results

The preliminary search resulted in over 200 records consisting of various articles, publications, and sources. After the preliminary search, a literature search was conducted using the search strategy; this involved an essential generation of the key terms and the use of the relevant keywords. As a result, around 100 full-text articles were retrieved. The PRISMA diagram shows the results of the literature search process.

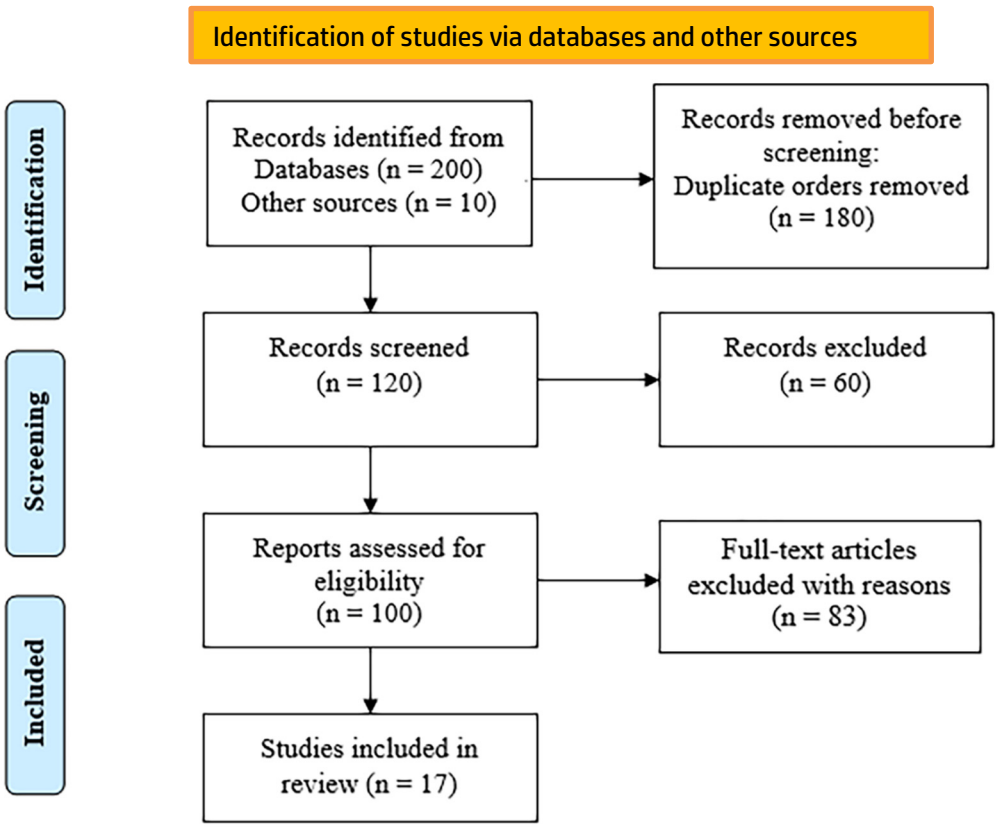

Figure 1. PRISMA Flow Chart

3. Results

3.1 Study Characteristics

In the initial phase of study selection, 200 studies were selected, which resulted in the final section of 17 articles based on their eligibility. Most of these studies were conducted at different hospitals or regions, while only a few were single-centered studies. Besides the selected studies, three were cross-sectional, two were retrospective, two were prospective, other two were observational studies,25,31 four were literature review based, three followed systematic review design,30,33,34. In contrast, only single research followed a case-control design.

Table 4. Characteristics of Included Studies

Name of Author	Year of Publication	Study Type	Study Methods and Sample Size	Final Outcomes
Andualem et al.	2020	Cross-Sectional Study	Seven hundred ninety-two participants were enrolled, which included a pair of mothers/caregivers and children with a mean age of 29.1 and 2.51 years, respectively.	The study's findings indicated unpaved roads at least 100m distance from the residence, living within the 100 m of heavy traffic, cockroach infestation, and new carpet in the house were the significant risk factors associated with the development of pneumonia in Ethiopia.
Shin et al.	2018	Retrospective study	The study collected data between 2007 and 2014 from the Emergency Departments in Korea. Children aged less than 12 months and between 1-3 years old were the most frequently diagnosed with the disease.	Findings indicated confirmed cases of Mycoplasma pneumoniae, bacterial pneumonia, pneumococcal. Pneumonia, M. pneumoniae pneumonia (MP) was majorly found among children.
Bokade et al.	2015	Observational longitudinal study	Two hundred ninety-nine children of age between 1-59 months presented with severe pneumonia were involved.	Among the involved sample, most participants were aged 1-6 months, while the most common risk factors included delayed hospital referral, refusal to feed, severe malnutrition, hypoglycemia, and incomplete immunization.
Roux et al. 26	2015	Retrospective study	A surveillance system was developed with the overall recorded pneumonia cases between 2012-2013 in the six public sector hospitals of South Africa.	The study's findings outlined 306 children affected with pneumonia episodes under one year of age, with overall episodes of 0.20. Most of the students had pneumonia lower than in the birth cohort.
Rhoades et al.	2018	Literature Review	A detailed review of the literature was presented to identify the available diagnostic modalities for bacteria and viruses, specifically in children's lower and upper respiratory tract.	Findings of the study indicated serological testing as the gold standard for testing Mycoplasma pneumoniae. Besides, pneumococcal antigen in urine is further considered to have low specificity in young children.

Awasthi et al.	2019	Cross-sectional prospective survey	In rural Lucknow, a cross-sectional survey was conducted between Feb to May 2016 to examine the overall proportion of hospitalized Community-Acquired Pneumonia (CAP) pneumonia cases. The study includes 3351 children from 2-59 months.	According to the findings incidence of CAP was high in the rural areas of Lucknow. Infants between 9-12 months were majorly affected by the disease compared to children aged between 12-59 months.
Grimwood et al.	2016	Review paper	A review was conducted to provide a detailed analysis regarding the preferred length of antibiotic treatment for children with pneumonia.	Through findings, it was suggested that antibiotic treatment in some instances might remain ineffective with increased chances of treatment failure resulting high mortality rate.
Ben-Shimol et al.	2014	Systematic review	A review was conducted based, and randomized controlled trials published between 1996-2013 were focused based on a sample of children below 18 years.	Findings indicated the inefficiency of oral antibiotic treatment in children with non-severe CAP, specifically in developed countries. Chest radiographies and laboratory tests were majorly preferred as the clinical criteria.
Khushwah, Verna, and Gaur	2018	Prospective Observational Study	Children between the ages of 1 and 60 months participated in the study at the pediatric emergency department of Gajra Medical College. Due to the pneumonia-like respiratory disease, 200 children were hospitalized.	In the overall sample, more than 50% had hypoxemia with typical symptoms of breathing difficulty, grunting, inability to feed, nasal flaring, head nodding, and sensitive crepitations.
Walker et al.	2013	Literature Review	The epidemiology of childhood pneumonia and diarrhea between 2010-2011 was reviewed.	Findings indicated an increased progression of pneumonia to severe episodes in children under five years. Zinc deficiency, undernutrition, and suboptimum breastfeeding.
Keleb et al.	2020	Cross-sectional study	Five-year-old children (n=576) from the peri-urban districts of Ethiopia's Dessie city were the subjects of a community-based study. To gather data, a pretested questionnaire was provided.	17.1% of the prevalence of pneumonia was found among children. Besides, significant symptoms included cough, fever, fast breastfeeding, chest indrawn etc. Other factors include; overcrowding, history of pneumonia, acute malnutrition, etc.
Beletew et al.	2020	Review paper	A review was done to assess the risk factors for pneumonia and its prevalence across the country of Eastern Africa.	The prevalence of pneumonia was 34%, while the common risk factors included a child being unvaccinated, cooking food in living rooms, using wood as a fuel source, a child's history of respiratory tract infection, etc.

Rudan et al.	2013	Systematic review	A systematic review was conducted to estimate the number of cases of pneumonia in 2010-2011 at the country level. An epidemiological model was developed.	Findings identified 0.22 episodes of childhood pneumonia per child in majorly middle and low incoming countries. In addition, influenza and respiratory syncytial virus were the most prevalent pathogens in children with pneumonia.
Agweyu et al.	2014	Prospective Study	To determine the pattern and severity of treatment failure, 385 children between the ages of 2-59 months with WHO-identified pneumonia and very severe pneumonia were monitored for five days.	Findings indicated the risks of treatment failure between 1.8% to 12.4% for severe pneumonia, while 39.9% of treatment failure was detected for very severe pneumonia. Besides, non-adherence to treatment guidelines was common among the majority of children.
McAllister et al.	2019	Systematic Review	A systematic review was conducted to estimate the mortality, morbidity, and risk factors associated with childhood pneumonia in developing countries at regional, global and national levels. Studies published between 2000 to 2015 were included.	Findings indicated a significant decrease in clinical pneumonia by up to 22% in 2000. However, in developing countries like Nigeria, India, Pakistan, Indonesia, and China, a significant rise in the cases of pneumonia was observed.
Azab et al.	2014	Prospective longitudinal Cohort Study	One thousand four hundred seventy children with a mean age of 5.4 years and diagnosed with CAO were included. Data were collected through patients' radiological findings and clinical data. Participants' socio and demographic variables were further compared for data analysis.	The study's findings identified factors including low family income, low maternal education level, parents' smoking habits, and unavailability of required medical care as independent risk factors associated with the prevalence of severe CAP among Egyptian children.
Hoang et al.	2019	Case-Control Study	The study included 2-59 months old children with pneumonia presented in the Pediatric Provincial Hospital of Thai Binh in Vietnam. Eighty-three children were included in each case and control group.	According to findings, antibiotics were least likely used in children with severe pneumonia. Besides, major risk factors included; exposure to cigarette smoke, weak immunization, and a low level of education in the mother. In addition, measles was common among children with severe pneumonia.

4. Analysis and Discussion

According to the latest data from the World Health Organization, pneumonia is still the single most significant cause of death worldwide, with an average of 15% annually. In 2017 alone, it led to the deaths of nearly 810,000 children (WHO, 2019). In addition, South Asia and Sub-saharan Africa interpretation for the utmost deaths and infections with pneumonia among children. A study by Theodoratou et al. (2014) was done on the prevalence of

pneumonia among children livings with HIV. It showed that children with HIV were indiscriminately susceptible to contracting severe pneumonia with an odds ratio of 6•5 (95% CI 5•9–7•2) compared to children without HIV.

Moreover, the mortality risk for children with pneumonia and HIV, as contrasted with those with pneumonia but without HIV, revealed an odd ratio of 5•9, 95% (CI 2•7–12•7). Yet, this was more prevalent in children living in low-income countries. 38 Additionally, it is established that the prevalence of pneumonia among children living with HIV is higher in the African continent than in any other region of the world (Theodoratou et al., 2014).

In the United States of America, one of the major causes of 1% to 4% of pediatric emergency department visits is pneumonia. Pneumonia is not only a leading cause of death in children in the United States of America but the same trend is found in Ethiopia. In a community-based cross-sectional study conducted by Andualem et al. (2020) 2018 in Gondar City in Northwest Ethiopia, from February 5 to June 20, 2019. Pretested, semi-structured questionnaires administered during in-person interviews at the participants' homes were used to gather the data. The prevalence of pneumonia among children under five was 12% when comparing 806 mother-child couples. Unpaved roads, living in a busy area, the custom of closing doors when cooking, and the presence of wet stains were some of the primary factors linked to the cause of pneumonia.

Additionally, it was discovered that the prevalence of pnemunia was correlated with a cockroach infestation, material wheezing, and having a new carpet in the home. Children were 1.98 times more likely to develop pneumonia in homes with cockroach infestations, whereas the likelihood of pneumonia was 1.75 times higher in homes with recently installed carpets. The study included a new understanding for policymakers on reducing pneumonia-related morbidity and mortality in children by managing interior and outdoor air pollution. Furthermore, it has been discovered that using vector control strategies and enhancing environmental cleanliness can aid in managing pneumonia.

The prevalence of pneumonia is particularly high in underdeveloped countries with poor sanitation and healthcare resources. The incidence rate of pediatric pneumonia and identifying pathogens for community-acquired pneumonia (CAP) is a basis for treatment, diagnosis, and intervention. The retrospective study between 1996 and 2005 determined that bacterial infections are one of the children's most common causes of pneumonia. Another retrospective and observational study were conducted in the subject area, and information from children and teenagers under 18 was collected. Results from the emergency room revealed that 329,380 children with a male to female ratio of 1:0.8 had pneumonia between January 2007 and December 2014. The findings indicated that children under three make up the majority of cases, while those aged three to thirteen make up a relatively more minor fraction. A total of 68 451 instances of pneumonia were reported annually in 2014, up from 30,521 cases in 2007. Of these, 1.1% were hospitalized, while the remainder were admitted to adult care. According to the report, hospitalization rates decreased from 63.4% to 38.2% in 2014, despite emergency department visits increasing from 2007 to 2014. According to the time series analysis, there was neither a rising nor a falling trend in the number of patients per 100,000 who had bacterial pneumonia, pleural effusion, pneumococcal pneumonia, and empyema from 2007 to 2014. An increase in the death ratio and an increasing trend of ICU hospitalized patients were observed in 7-12 years of children.

Community-acquired pneumonia is considered one of the leading causes of mortality and morbidity in the world's children. To define the trend of occurrence of pneumonia in developing countries, a two-year study was conducted in the tertiary care teaching hospital in central India. In total, 290 students were enrolled and divided into two groups: severe pneumonia and very severe pneumonia. The research results found that there is a significant incidence of pneumonia in people with low socio-economic backgrounds, even in developing countries. There is more significant mortality in the upper and lower socio-economic class. Then, the children with a lack of exclusive breastfeeding, incompletely immunized, and severe malnutrition was at a greater risk of pneumonia. Most cases were of refused feeding, lower respiratory rate, and delayed hospital referral.

In a study conducted in South Africa between 2012 and 2013 to identify the incidence rate of childhood pneumonia from health facilities as compared to active community-based surveillance, the researchers found that it was much less likely to record cases from a health facility than from an active surveillance program where 30% ratio difference was recorded.26 Whereas the research focused on infant children, researcher-made reference evidence that approximately 50% of children around the age of five years, who are already school-going children, do not visit health facilities when exposed to respiratory illnesses (Deutscher et al., 2012). However, pneumonia can be divided into three main groups based on the mode or location of acquisition, namely: pneumonia contracted in the community, pneumonia contracted in a hospital, and pneumonia contracted while using a ventilator, which can be brought on by viruses, bacteria, and fungi (Jain et al., 2020).

Of all the various causes and types of pneumonia that affect children, community-acquired pneumonia is the most

prevalent form amongst children in the global south and the single most significant cause of all pneumonia-related deaths among children (Baser & Colombo, 2019; Rudan et al., 2008). Relying on the World Health Organization, community-acquired pneumonia arises when fast breathing is detected above the normal rate of a given age-group-specific cut-off speed. The primary cause of community-acquired pneumonia is viral or bacterial etiology, whose treatment includes the prescription of antibiotics or immunization. Most community-acquired pneumonia deaths are caused by bacteriae such as Streptococcus pneumoniae (also called pneumococcal) and Haemophilus influenza type b. As a result, the usage of antibiotics has considerably contributed to a decrease in the global morbidity and mortality rate linked to community-acquired pneumonia.

However, there is now more widespread worry about the effects of extended antibiotic usage on the human immune system. This is because there is a growing number of evidence-based researches that shows that the prolonged use of antibiotics has resulted in the development of antibiotic-resistant strains on some of the commonly used antibiotics hence threatening the impact of antibiotics when used for treatment. Therefore, to treat community-acquired pneumonia caused by antibiotic-resistant bacteria, doctors must understand how to prescribe antibiotics for the right amount of time without damaging the body's immune system. However, it is recognized that there is little evidence, and the few clinical trials have critical limitations in establishing the optimal period of prescription of antibiotics in community-acquired pneumonia.

Generally, clinicians prefer to prescribe antibiotics for community-acquired pneumonia on a lower scale since the benefits associated with a shorter time include preventing the development of antibiotic resistance strain (Laupland & Valiquette, 2015). Since pneumonia is a respiratory disease, it is straightforward to confuse or miss its diagnosis in a pediatric emergency department with other respiratory diseases. For example, diagnosing pneumonia may be difficult for children with wheezing since the symptoms are closely related to other respiratory disorders such as asthma or bronchiolitis (Mathews et al., 2009). A decrease in oxygen pressure in the blood, a condition called hypoxemia, is often a result of pneumonia but may also result from other conditions such as asthma (Sarkar et al., 2017). Studies have shown that doctors in developing countries have found the inability to eat, cyanosis, grunting, and impaired consciousness to be among the most accurate clinical predictors of hypoxemia caused by pneumonia (Kushwah & Gaur, 2018). Although pneumonia is the most common cause of death in children, its symptoms and signs easily overlap with other respiratory and non-respiratory diseases such as malaria, making it difficult to diagnose (Scott et al., 2012). It is recommended that pneumonia be diagnosed based on the presence of fast breathing and lower chest indrawing or wheezing in the case of viral pneumonia, even when there is no fever.

It is advisable to ensure that chest radiography is obtained for proper diagnosis. Still, a computer tomography (CT) scan should be avoided, especially in cases of patients with suspected community-acquired pneumonia (2A). However, it may be used for recurrent pneumonia patients (Gupta et al., 2012).

6. Conclusion

This review helps us to understand the epidemiology of pneumonia amongst children. It is clear that despite the disease being the top cause of death among children, we are still unable to diagnose it on time to save enough lives. Nevertheless, most studies have focused on the impact, etiology, diagnosis, and management of community-acquired pneumonia in children below the age of five years. It is therefore important to develop the knowledge based on community-acquired pneumonia by looking into the best way to diagnose it using minimum resources, which is the norm in the global south where pneumonia is most prevalent. Therefore, addressing the different ways clinicians can identify community-acquired pneumonia without cutting-edge technology and using signs and symptoms would significantly lower the mortality rate of childhood pneumonia.

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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