Medical Research Archives

ESMED
European Society of Medicine

OPEN ACCESS

Published: December 31, 2022

Citation: Sigelman C. K., 2022. Flu, AIDS, and the Development of Intuitive Thinking about Disease, Medical Research Archives, [online] 10(11). https://doi.org/10.18103/mra.v10i12.3404

DOI:
https://doi.org/10.18103/mra.v10i12.3404

ISSN: 2375-1924

RESEARCH ARTICLE

Flu, AIDS, and the Development of Intuitive Thinking about Disease

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ABSTRACT

Despite the importance for their health and well-being of children's acquiring knowledge and understanding of disease, surprisingly little work has been done to compare children's thinking about different diseases at different ages to determine whether and how thinking about familiar diseases shapes thinking about newly encountered diseases. The present study reports a new analysis of interviews with 156 children that were conducted in 1992, when AIDS represented a new and life-threatening but not well understood health threat. The aim was to compare thinking about the causality of a familiar disease, influenza, and a then-unfamiliar disease, AIDS, among third, fifth, and seventh graders. Comparisons of the two diseases and three grade levels focused on: (a) level of understanding based on cognitive-developmental theory and (b) three features defining children's intuitive theories of disease (a biological ontology or vocabulary, causal propositions featuring an invisible germ or virus, and logical coherence). Scores on all four resulting summary measures and on all but one of eight causal propositions collectively constituting a scientific explanation of each disease, increased with age, with growth especially pronounced from third grade to fifth and seventh grades. Summary scores were moderately intercorrelated, both within each disease and across the two diseases. Folk beliefs about cold weather causing flu and casual contact causing AIDS declined with age. Levels of knowledge and understanding of the two diseases were more often similar than different. However, children's thinking about flu was ahead of their thinking about AIDS in some respects, especially among the youngest children and especially with respect to symptomology. At the same time, exposure to information during the AIDS epidemic appeared to enable children describing AIDS causality to replace the generic term *germ* used for flu with the more specific term *virus* and to better understand that a person must have a disease or its pathogen to transmit it, that the causal agent for a disease is disease-specific, and that the body resists germs and viruses. Implications for better understanding the development of disease concepts and filling gaps in children's knowledge and understanding in the era of COVID-19 are discussed.

Keywords: child development; intuitive theories; influenza; AIDS; causal thinking; knowledge

Introduction

Despite the ubiquity of infectious diseases and the capacity of some to cause long-term illness, disability, and death, remarkably little research has explored the development in childhood of understandings of diseases and their causality. Yet many children are affected personally by infectious diseases. Moreover, they hear about them and see other people in their lives affected. Children clearly need to be educated about major infectious diseases, not only so that they are better prepared when they or loved ones become ill but so that they can recognize risk factors for disease and begin at an early age to adopt effective preventive health behaviors. Research suggests that children—and adults as well—are more likely to adopt health promoting attitudes and behaviors when they understand, even in a basic way, the causality of a threat to health [1-5].

Despite a compelling case for educating children earlier and more thoroughly about diseases, little such education is provided to school children until adolescence, often in reaction to the outbreak of an epidemic, as when the then-novel threat of human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) dominated the attention of the public and health educators in the early 1990s [6]. Yet, through informal learning experiences starting before they enter school, children acquire a good deal of foundational knowledge about health and illness from which to construct more elaborated understandings, much of it organized around causal concepts [7,8].

In the present study, we examine, using a recently formulated approach to characterizing children's thinking about disease causality, data from interviews with children and adolescents conducted in the early 1990s about a familiar disease, influenza or flu, and a then much less familiar disease, AIDS. Like COVID-19 today, AIDS in the early 1990s, when it was reaching peak numbers of cases and deaths, was a new and deadly health threat that was poorly understood, aroused fear, and gave rise to many misconceptions. The present study's aim is to illuminate similarities and differences in children's knowledge and understanding, as well as misconceptions, regarding the causality of flu and AIDS across three grade levels. In the process, it aims to shed light on the extent to which thinking about a familiar disease, flu, may shape the development of thinking about a less familiar disease, AIDS—whether giving rise to sound knowledge or spawning misconceptions. Prior research on children's thinking about disease has most often been guided by Jean Piaget's theory of cognitive development and, more recently, by the intuitive or naïve theory approach to cognitive development, both of which guide the present analysis.

Piagetian Theory and Level of Causal Understanding

Piaget's theory [9] describes invariant stages that represent a universal developmental progression in the structural complexity or sophistication of logical thought. Cognitive-developmental studies of thinking about disease and illness have

therefore focused on the complexity of children's explanations rather than on their knowledge, or the factual correctness of their thoughts. Studies using similar Piagetian coding systems [10,11] have shown that understanding of illness causality progresses through levels ranging from vague and magical thinking in the preschool years (Piaget's preoperational stage), to awareness in elementary school that a disease agent such as a germ is internalized and causes sickness (concrete operational stage), and to more complex, physiological explanations in adolescence featuring interacting causes and effects within the body (formal operational stage). Level of understanding, whether of illness in general or of particular diseases, is indeed associated with both age and performance on Piagetian tasks assessing cognitive development [11-15]. From a cognitive-developmental perspective, providing children with factual knowledge about how people get a disease is not sufficient; children must also understand the causal processes involved [14,15].

The Intuitive Theories Perspective and Causal Knowledge

The intuitive or naïve theories perspective on cognitive development holds that, from an early age, children have or construct foundational theories that organize their knowledge of the physical, biological, and psychological worlds [7,8,16]. Intuitive theories define a domain of knowledge, specify the causal explanatory mechanisms that operate in that domain, and integrate thinking in a coherent way [16]. Researchers guided by the intuitive theories perspective as applied to concepts of disease have been concerned more with the content and correctness of children's thinking than with its logical complexity. They have paid special attention to when children have a truly biological theory of infectious disease centered around a concept of germs as invisible biological entities that are transmitted from person to person and cause disease [1].

From this perspective, important intuitions about disease are in place starting in the preschool years, when children are often familiar with the concept of germs as disease-causing agents, although they may or may not understand them as biological in nature [17,18] and may believe that a nondescript germ can cause a variety of illnesses rather than understanding that germs and viruses are disease-specific [19,20]. From the intuitive theories perspective, if children are given accurate biological information, they may not need to have attained an advanced level of cognitive development in order to grasp the information needed to construct a scientifically correct theory of what causes a disease [1].

In laying out this approach to cognitive development, Wellman and Gelman [16] identified the following key features of an intuitive theory in a domain such as biology: (a) an ontology, or vocabulary of entities and concepts that fall within the domain, (b) domain-specific causal mechanisms, (c) unobservables, or invisible underlying constructs that help explain phenomena, and

(d) coherence, or an organization of and interrelatedness among concepts.

In order to advance the intuitive theories perspective as applied to children's thinking about infectious diseases, Sigelman and Glaser [21], following Wellman and Gelman [16], assessed children's intuitive theories of infectious disease by determining whether they: (a) command a disease-relevant biological ontology (e.g., use terms such as *germ* and *immune system*); (b) can explain illness causality and, in the process, invoke an invisible disease agent such as a germ or virus as the causal mechanism; and (c) demonstrate a coherent linking together of ideas in their explanations. A mature, scientific intuitive theory of disease would be both causally sophisticated and scientifically correct with respect to ontology, causal mechanisms involving an unobservable disease agent, and coherence. Sigelman and Glaser [21] applied their intuitive theories model to flu. In the present study, applications of the model to flu and AIDS are compared.

Knowledge and Understanding of Flu

There is good reason to expect both level of understanding of flu in the Piagetian sense and knowledge of flu in the intuitive theories sense to increase steadily with age in childhood and adolescence thanks to informal and formal education and cognitive growth [12,21-23]. However, the literature on children's thinking about flu is small and there is much to learn. Most children aged 6 to 12 appear to have heard of flu and can name some of its symptoms [24]. Factual knowledge about upper respiratory illnesses increases with age during the elementary school years, especially between fourth and sixth grade [25]. Analyzing students' "concept maps" of flu, Jones and Rua [26] found further growth from fifth to eleventh grade and concluded that children and adolescents know a lot about flu transmission routes and symptoms but less about the immune system, vaccines, and medications.

Guided by the intuitive theories perspective and focusing on coexisting folk and scientific theories of colds and flu, Sigelman [23] found that, although cold weather thinking was more common for colds than for flu, it declined with age as germ theories became more prominent. Au et al [2] asked Chinese third graders and young and elderly adults about colds and flu jointly and found many children and elderly adults cited cold weather causes of respiratory illnesses while recognizing germs as a cause as well. Teaching third and fourth graders that germs live a long time in cold weather but are killed by heat and can cause illness only when they are alive reduced cold weather explanations and enabled children to think more coherently about the biology of cold/flu causality.

Analyzing open-ended interviews with children aged 8 to 13 about the causality of flu, Sigelman and Glaser [21] documented increases with age in Piagetian causal understanding as well as in use of terms associated with a disease-relevant biological ontology and expression of causal propositions explaining how someone gets flu and develops symptoms, but found that few children mentioned the idea of the virus

multiplying or spreading in the body or of an immune system responding to it.

Knowledge and Understanding of AIDS

The AIDS epidemic that dominated the news in the late 1980s and 1990s stimulated considerable research on children's knowledge and understanding of HIV/AIDS. Knowledge of the AIDS "germ," HIV, progresses with age from viewing it as a nondescript germ to appreciating that it is disease-specific and has specific characteristics [1,27]. Both causal understanding and knowledge of AIDS increase with age and are interrelated [14,28-29]. By ages 7 to 10, many children understand that internalizing germs causes AIDS, although they typically cannot say how, and a minority of adolescents talk about multiple, interacting causal factors [15]. Moreover, understanding of causality is correlated with understanding of prevention and treatment [14], and knowledge of risk factors for AIDS and its viral causality predict knowledge of prevention rules and willingness to interact with people with AIDS [30], signs of coherence in thinking.

In a study particularly relevant to the present analysis, South African children ranging in age from 5 to 15 and adults were interviewed about both AIDS and flu by Legare and Gelman [22], who were guided by both the Piagetian and intuitive theories perspectives. Piagetian understanding increased with age for disease causality, although not for prevention and treatment. Most participants grasped the concept of internalization of a disease agent but were unable to explain the internal biology of disease. Whereas among elementary school children in the U. S. understanding of the causality of colds was ahead of understanding of the causality of AIDS developmentally [14], South African children understood AIDS causality better than flu causality, possibly because AIDS was a widely publicized and serious threat in South Africa at the time [22]. Content analysis of themes suggested that children of all ages associated flu with casual contagion and, with age, increasingly associated AIDS with blood and sexual contact rather than casual contagion.

The Coexistence of Scientific and Folk Beliefs

Unlike the Piagetian perspective, in which a new mode of thinking replaces an earlier, less mature one, the intuitive theories perspective allows for the holding of multiple theories simultaneously [31]. Indeed, research has established the coexistence of theories of illness—notably, the germ theory and the cold weather theory [23,32], or the germ theory and a supernatural theory [31,33]. Although folk beliefs typically decrease with age as scientific theories are mastered, they sometimes live on to coexist with scientific theories rather than being replaced by them, even among many adults [34,35]. Thus, comparing the development of children's thinking about flu and AIDS requires attention to folk theories and the misconceptions associated with them.

As noted above, cold weather thinking about colds and flu declines with age as germ theories became more prominent [23]. Similarly, myths about casual contagion of AIDS through kissing, being breathed on by a

person with AIDS, and the like, while reasonable inferences based on a general germ theory of disease, decrease with age as children solidify their knowledge of true risk behaviors [28,29, 36]. Also likely to decrease with age are AIDS-specific misconceptions such as the idea that almost any kind of substance use (smoking and drinking included), sexual activity, or activity involving blood can cause AIDS [36].

The Present Study

Despite evidence that Piagetian understanding and mastery of scientifically accurate intuitive theories of disease both increase with age from early childhood to adolescence, we do not yet know whether children confronted with an unfamiliar disease try to understand it by applying a general theory of infectious disease or one or another disease-specific theory to it. Ideally, they would develop a hierarchically-organized knowledge base in which broad principles (e.g., "it's caught from other people," and "a disease-causing agent is internalized") are applied to newly encountered diseases and then corrections to this working theory are made as necessary in response to new information if, for example, the modes of transmission of the new disease differ from those represented in the general infectious disease theory children may have constructed. More simply, children might directly apply what they know of common diseases such as colds and flu to a new disease. This appears to have happened when AIDS first came on the scene, breeding casual contagion myths that made children fearful they could catch AIDS from sharing food or sitting near a child with AIDS in class [28,29]. We can learn much about how children formulate ideas about a newly emerging disease such as AIDS—or, more recently, COVID-19—from a direct comparison of children's thinking about new and familiar diseases.

Data for the present study were collected in a unique historical/cultural context: the United States in 1992, when AIDS was still becoming known to the public and was killing many Americans, including children. Los Angeles Lakers basketball superstar Earvin "Magic Johnson" announced that he was HIV-infected on November 7, 1991, an event that was widely publicized. Extensive media coverage of HIV and AIDS when our interviews about AIDS and flu were conducted provided an opportunity to study whether knowledge of familiar diseases such as flu informs knowledge of less familiar diseases such as AIDS and whether acquiring knowledge of a widely discussed and frightening new disease such as AIDS has the power to alter understanding of familiar diseases.

The aim of the present study was to use the model for assessing children's intuitive theories of infectious disease developed by Sigelman and Glaser [21] and applied by them to flu to systematically compare children's knowledge and understandings of flu and AIDS at three different ages and to test the following hypotheses:

1. Scores on both a Piagetian measure of level of understanding of disease causality and intuitive theory scores

reflecting ontology, causal propositions that compose a scientific theory of infectious disease, and coherence of thinking will increase similarly with age for flu and AIDS. That is, older children will think in more complex ways, command a more complete biological vocabulary, better communicate the causality of infectious illness in terms of the internalization and action of germs to produce disease symptoms, and tie their ideas together more coherently.

2. Different measures of children's thinking about each disease will be intercorrelated, and thinking about flu will be positively correlated with thinking about AIDS, suggesting that common understandings underlie theories of these distinct infectious diseases.
3. Scores reflecting common folk beliefs—specifically, cold weather thinking about flu and casual contagion myths about AIDS—will coexist with germ theories in the thinking of young children but will decrease in strength with age.
4. Finally, lacking a firm basis for hypothesizing, we pose this research question: How are knowledge and understanding of flu and AIDS similar and different, and what might be the implications of children's thinking about one for their thinking about the other? Because children are likely to have had more personal experience with flu, and because at least one study found children's causal understanding of colds to be ahead of their causal understanding of AIDS [14], it was tempting to hypothesize that knowledge and understanding of flu will be more advanced than knowledge and understanding of AIDS and may shape thinking about AIDS. However, the finding that high awareness of and concern about AIDS in South Africa may have been responsible for children there showing greater causal understanding of AIDS than flu [22], leaves us uncertain what to predict.

Method

Participants

Interviews were conducted with 156 children in third, fifth, and seventh grades (with *n*s of 55, 52, and 49, respectively). A power analysis indicated that an *N* of at least 150 with alpha set at .05 would have power of .85 to detect a low-medium effect size of .25 in our planned analyses of variance involving the two diseases examined at three grade levels. The children were recruited from 12 classrooms in three Catholic elementary schools in a southwestern city in the U. S. that were chosen because of their diverse student bodies. The students on which this report is based were randomly selected from the students in a larger AIDS education intervention study conducted in 1992 to be interviewed individually about the causality of both AIDS and flu in the pretest phase of the larger project. The larger sample from which interviewees were chosen represented 87% of the students who were given packets with parent consent forms and parent surveys to take home.

Mean ages of the three grade groups were 8.8, 10.7, and 12.6, respectively. Of the 61 males and 95 females in the sample, 35.4% were European American; 58.9% were Latino/a, primarily Mexican-American; and the remaining 5.7% were other minorities (African-American, Asian-American, or Native-American). Socioeconomic backgrounds were varied: Parent education ranged from 5 years to post-graduate degrees and averaged 14.3 years (the equivalent of some college or completion of an associate degree or technical training program after high school), and 29% of the children qualified for the school free lunch program available to low-income children.

According to parents, 64.5% of the children had received no AIDS education in school or elsewhere; 24.3% had received less than a single class period of instruction; and only 11.3% had received one class period or more of instruction. The percentages who received any AIDS education were low: 24%, 44%, and 40% for the three grade levels, respectively.

Measures

In focused open-ended interviews conducted at school, students were asked five basic questions, supplemented by a planned strategy of follow-up probing, to assess their thinking about how people get AIDS and flu. Questions concerned: (1) what the disease is, (2) a way someone could get it, (3) how the risk behavior or exposure to risk mentioned by the child would give someone the disease exactly (and, in a planned follow-up question, whether something gets in their body that makes them get sick and, if so, what it is; or if not, what *does* happen to make them sick), (4) what happens to people who get AIDS or flu (i.e., what symptoms result), and (5) how the disease agent identified by the child works to make the person experience the main symptoms mentioned by the child. Interviewers probed for more specific answers where appropriate (e.g., Can you say more about what you mean by "from other people"? How does that work?), encouraging children to flesh out each part of the causal account they were constructing. The order of the flu and AIDS interviews was counterbalanced, but order of administration did not influence findings on the main measures [21].

Level of Understanding

The systems developed by Bibace and Walsh [10,15] were adapted for this study to code levels of conceptual understanding of illness: (0) no response or don't know, (1) a largely magical association between some phenomenon and illness, (2) the association of a specific cause and a specific effect without causal explanation, (3) an account of how an external cause leads to internalization of a disease agent and symptoms, (4) a mechanistic sequence of specific causes leading to specific changes in internal organs/processes and in turn symptoms, (5) an entire causal sequence involving interactions of multiple causes and effects, with the body playing an active role, and (6) a full physiological explanation involving interacting causes and effects. This coding yielded a level of understanding score that

could range from 0 to 6, with 6 representing maximum causal sophistication--although not necessarily correct factual knowledge. As in previous studies [14,22], level of understanding was treated as an interval scale for purposes of analysis.

Intuitive Theories

Using the methodology for characterizing intuitive theories of infectious diseases in terms of both scientific correctness and causal explanatory sophistication devised by Sigelman and Glaser [21], original codings of interview responses regarding both flu and AIDS were recoded and combined to create measures ontology, causal propositions, and coherence. The coding system used to characterize intuitive theories of flu by Sigelman and Glaser [21] was modified in minor ways as shown below to apply to AIDS as well.

Ontology

To assess whether children had knowledge of a biological vocabulary relevant to disease, we scored as 0 (not mentioned) or 1 (mentioned) each child's use of five terms in their flu (or AIDS) interview: *germ*, *virus*, *immune* or *immune system*, *white blood cell*, and *cell* of any sort. The ontology score was the average of the five items—i.e., the proportion of the five concepts mentioned.

Causal Propositions

The second measure, also a proportion correct index, assessed a child's causal explanatory framework by scoring the presence or absence of eight propositions judged to be key elements in a scientifically correct and complete account of how exposure to risk results in at least one recognized symptom of disease. As such, this measure assessed expression of scientifically correct propositions regarding how one gets flu or AIDS, what happens in the body to produce symptoms, and what those symptoms are likely to be. Each proposition was coded 0 (not mentioned) or 1 (mentioned) and the codings were averaged to form a total score that could range from 0 to 1. Although mastery of the eight propositions primarily represents accurate knowledge, it likely reflects conceptual understanding as well in the sense that the child with a high score has assembled—although not necessarily woven together in a tight causal argument—the elements needed to construct a biologically correct explanation:

1. You get the disease from other people: for flu, mention of saliva/mouth contact, physical contact, or airborne contact (e.g., being sneezed on) as the route of transmission; for AIDS, mention of sex with an infected person, drug needle sharing, or transmission through blood.
2. The other person must have the disease (or disease agent).
3. The contact results in internalizing a disease agent: the child can explain a process of internalization, even if the disease agent is not correctly identified.
4. The disease agent is a germ, virus, or similar biological entity: a correct answer did not require

labeling it as a *flu* germ or the *HIV* virus).

5. The disease agent spreads or multiplies inside the body.
6. The disease agent does damages in the body: the child may describe the agent hurting or upsetting the body only vaguely or discuss it attacking specific body parts or cells associated with symptoms.
7. Symptoms are experienced: for flu, the child mentions at least one likely head or stomach flu symptom (e.g., tiredness, headache, coughing, sneezing, runny nose, diarrhea, vomiting, stomach ache, general achiness, fever), based on the Center for Disease Control and Prevention list of influenza symptoms [37]; for AIDS, following the Centers for Disease Control and Prevention description of AIDS symptoms [38], which includes flu-like symptoms initially and varied symptoms thereafter, we counted any of the following as correct: tiredness, head cold symptoms, general flu symptoms such as aches, weight loss, or fever, and AIDS-specific symptoms such as purple sores, night sweats, or the like.
8. The body fights the disease agent: the child describes, whether the immune system is named or not, the body resisting the disease agent or disease or the idea that symptoms result in part from the immune system's defense.

Coherence

Guided by the concept of coherence as an "interrelatedness of ideas" [16], we created a measure of the logical coherence of the child's account of disease causality—whether the child's ideas, right or wrong, are connected to one another in a logical causal argument.

Two codings were averaged to form this score. The two codings were intended to be similar and were in fact highly correlated, r (155) = .81, $p < .001$ for flu, r (155) = .80, $p < .001$ for AIDS. The first coding assessed the linking of a disease agent to damage to the body and damage to the body, in turn, to symptoms, creating at least a rough causal chain. The second coding of the logical tightness of the child's explanation did not require identification of damage to the body as a mediator of the effect of the disease agent and was intended to give credit to other lines of explanation (e.g., a behavioral or psychological one). Both codings had values of 0 (no explanation), 1 (partial explanation, e.g., connecting disease agent to damage to the body or damage to an identified symptom but not both), or 2 (full causal argument with all elements in the causal chain connected); see Sigelman and Glaser [21]. The final coherence score averaging the two codings could range from 0 to 2.

Folk Beliefs and Misconceptions

We also assessed the expression of incorrect folk theories about each disease, as revealed by coding various types of correct and incorrect risk factors as mentioned (1) or not mentioned (0). As discussed earlier, the most common folk belief about flu attributes it to cold weather, rapid temperature changes, or similar cold or hot temperature exposures. We also explored whether, given widespread coverage of AIDS, some children cited true AIDS risk factors as causes of flu.

The most common folk beliefs about AIDS claim that casual contact can transmit HIV. We therefore examined associations of AIDS with the three major risk factors for flu (saliva, physical contact, and airborne transmission), as well as with indirect contact through toilet seats and the like and remote proximity (e.g., being near, going to the same school as someone with the disease). Because some children also appear to overgeneralize from drug needle sharing to almost any form of substance use [36], we coded mentions of smoking, drinking, and marijuana use.

Coding Reliability

The original codings of each interview were done soon after the interviews were completed and transcribed. Two coders from a pool of seven trained coders who were blind to the age of the interviewee coded each flu or AIDS interview independently and reached a consensus on disagreements before assigning final codes. For this analysis, we combined original variables and collapsed coding categories in various ways to create new intuitive theory scores and had a new trained coder code the new variables for a random sample of 25 interviews. Her codings of the new variables were then cross-tabulated with scores on these variables calculated from the original codings.

Interrater agreement for Piagetian level of understanding (exact agreement on the 0-to-6 score), as established by the original coders, was moderate: 71% for AIDS, 67% for flu [27]. We therefore used the final scores agreed to by each pair of coders after they had discussed their disagreements. Agreement percentages and Cohen's *kappa* coefficients (which correct for chance agreement) involving the new coder were calculated for the intuitive theory measures [21]. For ontology, agreement was 92% ($\kappa = .88$); for causal proposition items, agreement averaged 96% (average $\kappa = .87$); and for the coherence score, agreement was 84% ($\kappa = .77$). All *kappa*s were significant at $p < .001$ or beyond. Finally, for folk beliefs about risk factors, interrater agreement for the original coders averaged 98% across risk factor categories [23].

Results

We first determined whether children knew what flu and AIDS were. Percentages of children in third, fifth, and seventh grades who at least implied that flu is a sickness, disease, illness, or virus in response to an open-ended question were 83.6%, 94.2%, and 98.0%, respectively, a significant increase with age, χ^2 $(2, N = 156) = 7.63$, $p < .05$. Children who gave unclear responses or did not know, mostly third graders, were asked a simpler multiple-choice question and all passed.

Percentages correctly answering the open-ended question about AIDS were similarly high: 78.2%, 94.2%, and 93.9% across the three grades, χ^2 (2, N = 156) = 8.80, $p < .05$; all but two of those who could not answer correctly passed the multiple-choice question.

Differences in Summary Measures by Grade Level and Disease

Table 1 presents means of the four summary measures for flu and AIDS at each grade level. Each measure was analyzed using a 3 (grade level, 3rd vs. 5th vs. 7th) x 2 (disease, flu vs. AIDS) analysis of variance, run in the SPSS Version 26 MANOVA program with grade as a between-subjects factor and disease as a within-subjects factor. Follow-up tests for simple effects guided the following narrative summary.

Table 1. Means and ANOVA Statistics for the Four Summary Measures for AIDS and Flu

Variable	Grade			*F* Statistic		
	3rd	5th	7th	Grade	Disease	Grade x Disease
Piagetian Understanding						
Flu	2.96	3.37	3.47	14.29***	ns	3.35*
AIDS	2.69	3.54	3.45			
Ontology						
Flu	.10	.24	.33	35.38***	ns	ns
AIDS	.14	.25	.36			
Causal Propositions						
Flu	.42	.61	.70	48.85***	ns	3.83*
AIDS	.34	.65	.69			
Coherence of Thinking						
Flu	.74	.95	.96	7.43***	ns	ns
AIDS	.62	1.95	.99			

Note: Piagetian level of understanding has a potential range of 0 to 6; ontology score is the proportion of five disease-relevant biological terms used; causal proposition score is the average of eight 0 (not mentioned) and 1 (mentioned) proposition codes; coherence is the average of two 0-to-2 codings of the completeness of causal linkages leading from exposure to a disease agent to symptoms. Degrees of freedom in ANOVAs were 2 and 152 for grade, 1 and 152 for disease. Some means for flu in Tables 1 and 2 differ slightly from those in Sigelman and Glaser [21] because one third grader did not complete the AIDS interview.

*$p < .05$ **$p < .01$ ***$p < .001$

Scores on the Piagetian understanding measure increased significantly from third to fifth and seventh grades for both diseases; scores were similar for flu and AIDS but the grade x disease interaction was significant, indicating that patterns of development for the two diseases differed. Further analysis showed that the youngest children showed greater understanding of flu than of AIDS ($p < .05$), whereas fifth graders and seventh graders understood the two diseases about equally well. Looking more closely at the specific levels of thinking children showed, most children (53.5% across grades for flu, 50.3% for AIDS) expressed at least a vague understanding that something gets inside the body (level 3 understanding), and another 35.5% for flu and 35.5% for AIDS were able to describe an external cause, an internalized disease agent, and something going on in the body underlying the emergence of symptoms (level 4); most of the rest scored at level 2 or lower. Very few, only 1.3% for flu and 3.9% for AIDS, scored at level 5 and gave a sophisticated explanation involving multiple interacting influences.

Ontology scores increased significantly from third to fifth grade and again from fifth to seventh grade, and were similar for the two diseases overall. Even seventh graders used only about one or two of the five disease-related terms counted in this score on average. In the flu interviews, 59.4% of the sample referred to *germs* somewhere in their interview, 24.5% to a *virus*, 16.8% to *cells*, 6.5% to *immune* or *immune system*, and 1.9% to *white blood cells*. The parallel figures for AIDS were 34.8% for *germs*, 47.7% for *virus*, 25.2% for *cells*, 11.0% for *immune system*, and 4.5% for *white blood cells*. Children spoke of germs significantly more for flu than for AIDS but of viruses and the remaining three biological terms more for AIDS than for flu ($ps < .001$).

Causal proposition scores increased significantly from third grade to the two higher grades, with seventh graders communicating about 70% of the eight propositions for both diseases. The 3 x 2 ANOVA revealed no overall difference between the two diseases, but grade and disease interacted, much as for Piagetian understanding, such that third graders knew significantly more about flu than about AIDS ($p < .05$) whereas older children had equal knowledge of the two diseases.

Coherence scores also increased significantly with age from the youngest to the two older groups and were similar for the two diseases but were low (i.e., at the midpoint on average on a scale from 0 to 2), even in the two oldest age groups. Most children could construct part but not all of a logical, connected causal argument.

To further examine similarities and differences in thinking about the two diseases, partial correlations controlling for age were calculated among the four flu and four AIDS summary measures. These partial correlations were moderate in size and statistically significant. Scoring well on one measure for flu or AIDS was associated with scoring well on the other three (partial rs of .20 to .54 for flu, all significant and all but .20 significant at

$p < .001$; and partial rs of .26 to .60 for AIDS, all significant at $p < .001$). The partial correlations between Piagetian level of understanding and causal propositions were especially high, those between ontology and coherence lowest. Finally, the partial correlations between the corresponding measures for flu and AIDS, all significant at $p < .001$, were .44 for level of understanding, .35 for ontology, .41 for causal propositions, and .32 for coherence.

Specific Causal Propositions

Table 2 elaborates on mastery of causal propositions by detailing how well the eight propositions that constitute a scientifically accurate theory of flu or AIDS were represented in children's explanations at each grade level. The picture conveyed is of consistent improvement with age, especially from third to fifth and seventh grades. Increases with age in scientific theory-relevant propositions were significant for all propositions except the proposition that the disease agent spreads and/or multiplies within the body, which did not improve with age and was mentioned by fewer than half the students even in seventh grade.

Table 2. Mean Proportion of Students Conveying Each Causal Proposition by Grade and Disease

Variable	Grade			*F* Statistic		
	3rd	5th	7th	Grade	Disease	Grade x Disease
(1) Get it from contact with other people						
Flu	.54	.79	.88	31.74***	ns	ns
AIDS	.41	.87	.94			
(2) Other person must have disease						
Flu	.35	.42	.65	14.25***	19.73***	ns
AIDS	.46	.79	.86			
(3) Internalize a disease agent						
Flu	.48	.69	.88	21.60***	ns	ns
AIDS	.43	.77	.86			
(4) Disease agent is germ or virus						
Flu	.46	.83	.92	16.57***	ns	ns
AIDS	.56	.79	.82			
(5) Agent spreads or multiplies in body						
Flu	.33	.42	.41	ns	ns	ns
AIDS	.30	.50	.35			
(6) Agent damages or hurts something in body						
Flu	.30	.67	.61	15.40***	ns	
AIDS	.32	.65	.67			
(7) Symptoms appear						
Flu	.87	.96	.98	18.08***	125.30***	7.10***
AIDS	.18	.62	.61			
(8) Body fights disease agent						
Flu	.06	.12	.29	13.31***	6.98**	ns
AIDS	.06	.21	.45			

Note: Each causal proposition score was coded 0 (not mentioned) or 1 (mentioned) so each entry is the proportion of children communicating a proposition in some way. Degrees of freedom in ANOVAs were 2 and 152 for grade, 1 and 152 for disease.

*$p < .05$ **$p < .01$ ***$p < .001$

About half of third graders cited at least one relevant risk factor involving contact with other people (or with the virus) for each disease, and knowledge increased similarly with age for both diseases. Flu was most often attributed to airborne transmission (54.5%) or saliva (21.2%). AIDS was correctly associated with sex with an infected person (49.7%) and contact with infected blood (42.6%), and to a lesser extent with drug needle sharing (22.6%). These three AIDS risk behaviors were never cited as causes of flu. Fewer than half of the third graders communicated that the person from whom someone gets flu or AIDS must have the disease or virus. Communication of this concept improved with age, and, as indicated by the significant *F* for disease, children were significantly more likely to communicate it for AIDS (70% overall) than for flu (47% overall).

Large improvements were also seen from third to fifth and seventh grades in communication that a disease agent of some kind is internalized and that this causal agent is a germ or virus. A closer look at specific answers given, however, revealed that only a few children explicitly said that the germ or virus involved was a disease-specific virus. Proportions doing so were 0.00, .14, and .14 across the three grade levels for flu, compared with .15, .33, and .25 across the three grade levels for AIDS. Both the increase with age, $F(2, 152) = 4.77$, $p < .01$, and the greater awareness of an AIDS-specific virus than of a flu-specific virus, 24% versus 9% overall, $F(1, 152) = 15.33$, $p < .0001$, were significant.

Awareness that the disease agent hurts or damages something in the body increased with age from third to fifth and seventh grade. As for symptomatology, at least one flu symptom was described by high proportions of all age groups, whereas AIDS symptoms were less often mentioned and mentions increased steeply with age from third to fifth and seventh grades, resulting in significant grade, disease, and grade x disease effects in the ANOVA. The most commonly mentioned flu symptoms across grade levels were respiratory symptoms typically associated with colds (55.1%), followed by stomach-related symptoms (46.2%), suggesting that both respiratory and gastrointestinal symptoms were prominent in children's models of flu. AIDS symptoms were less understood: 50.3% of the sample gave "don't know" or vague responses (e.g., "they feel sick," "they need to go to a doctor"); another 15.5% named a specific symptom but not one associated with AIDS. Most correct responses were "tired or weak" (28.4%) and other flu-related symptoms. Coders also recorded mentions of death as an effect of each disease. Overall, 40% of children said AIDS kills people, but only 1.9% mentioned that flu can kill people.

Finally, the least mastered of the eight causal propositions was that the body fights the disease agent; even among the adolescents aged 12-13, only 29% referred in some manner to the body defending itself against flu, whereas more, 45%, said something about the immune system or the body resisting the virus or being damaged by

it when talking about AIDS. Both the age group difference and the overall edge in favor of AIDS over flu were significant.

Folk Beliefs and Misconceptions

Exposure to cold weather or temperature changes as a risk factor for flu was mentioned by 21.9% of the sample. The myth was common among both third and fifth graders (25.4% and 30.8%, respectively), but diminished by seventh grade (10.2%), F (2, 152) = 3.67, $p < .05$.

Regarding AIDS, cold weather was never mentioned as a risk factor. However, young children were more likely than older children and adolescents to express casual contagion myths, claiming that one or the other of the three main causes of flu could cause AIDS, 31.5% vs. 19.2% vs. 4.1%, F (2,152) = 6.78, $p < .01$. Fewer than 5% of the sample mentioned some form of remote or indirect proximity to someone with AIDS or substance use other than drug needle sharing.

Discussion

The present study supports the value of using the methodology for characterizing children's intuitive theories of infectious disease developed and applied to flu by Sigelman and Glaser [21], based on a conceptualization of children's intuitive theories by Wellman and Gelman [16], to compare thinking about flu and AIDS at different ages, including folk beliefs that coexist with children's emerging scientific theories of the two diseases. Overall, accurate knowledge and causal understanding of both diseases improved considerably with age and common folk beliefs declined, and both similarities and differences between conceptions of the two diseases were identified.

The levels of understanding measure based on cognitive-developmental theory, while limited in the sense that it focuses only on logical complexity and ignores correctness, contributes to a picture of how causal explanations of disease become more logically complex with age. Application of the intuitive theories perspective [16] resulted in characterizing the growth of theories further in terms their disease-relevant biological ontology, statement of causal propositions consistent with a scientific theory of infectious disease, and logical coherence.

The findings clearly reinforce prior evidence that both knowledge and causal understanding of diseases increase with age [14,22,25,29]. Specifically, level of understanding in the Piagetian sense increased with age and, as their intuitive theories developed, children commanded a more complete biological vocabulary, were more likely to grasp infectious illnesses in terms of the internalization and action of germs or viruses, and presented more coherent explanations. On a more negative note, their levels of understanding generally fell at levels 3 and 4, as in similar studies [15,22], suggesting that few students reached an understanding of interacting causal forces within the body, expressed awareness of germs or viruses replicating inside the body, or conceptualized an immune system resisting viruses or being affected by them [22,39] (but also see Toyama [40]

for evidence that some children believe that the body's energy to resist illness can be compromised by unhealthy lifestyle factors). As both knowledge and understanding increased with age, folk beliefs and misconceptions, as expected, decreased. Most notably, children became less likely to maintain that cold weather causes flu and that AIDS can be transmitted through the same mechanisms of casual contagion that cause flu.

As expected based on prior research [14], the four scores used to summarize thinking were moderately correlated, both within each disease and between the two diseases. This suggests that each intuitive theory measure adds unique information to what the Piagetian measure of understanding reveals and that thinking about one disease has commonalities with thinking about other diseases. The interdependence implied by the correlations between knowledge measures (primarily ontology and causal propositions) and logical sophistication measures (Piagetian level of understanding and coherence) is consistent with theorizing that knowledge and the capacity for causal thought complement and advance one another in development [16]. That is, advances in cognitive development enable children to better assimilate and organize new information, and exposure to new information helps them think in more sophisticated ways.

Systematic comparisons of knowledge and understanding of the two diseases yielded a mixed picture with respect to which disease was better understood. For the most part, they were understood—or, for some measures, not understood—equally well. The data did not strongly support the notion that grasp of the more familiar disease, flu, is more solid than, and likely influences, grasp of the less familiar disease, AIDS, except to some extent among the youngest children (ages 8 and 9). Both level of understanding and causal proposition scores were significantly higher for flu than for AIDS in third grade. Possibly this was because children this young were not as exposed to media coverage and family and peer discussion of AIDS as older children were and therefore knew less about it and were forced to draw on their knowledge of colds, flu, and other common childhood diseases by default. Knowledge of flu symptoms was also more advanced than knowledge of AIDS symptoms, especially among the youngest children, although this can be attributed not only to flu being the more familiar disease but also to the fact that AIDS symptoms are more varied because they result from a wide range of opportunistic infections.

Yet the findings also suggest that widespread attention to HIV/AIDS in the early 1990s advanced children's explanations of AIDS. Thus, the present study supports to some extent both an earlier finding that colds are understood better than AIDS [14] and an earlier finding that AIDS, at least during a life-threatening AIDS epidemic, is better understood than flu [22]. In support of the latter, children less often referred to germs and more often spoke of viruses and other biological concepts in discussing AIDS; better understood that a person must have a disease or virus to transmit it; were more aware that a

disease-specific virus is implicated in AIDS; better understood, in the two oldest groups at least, that the body fights viruses; and were more aware that AIDS kills people, although flu does too. We likely see here the impacts of extensive publicity and informal learning through social interactions on knowledge about HIV/AIDS. According to parents' reports, few children in this sample received any formal AIDS education at all, and a check of correlations indicated that those who did receive it had no better knowledge and understanding than those who did not. Importantly, whatever learning experiences children had about AIDS did not appear to color their thinking about flu in the least; for example, no child suggested that sex, contact with blood, or drug needle sharing cause flu. It seems likely, then, that children take factual information about a novel disease to be specific to that disease, although they likely interpret such information in the context of the sketchy theory of infectious disease they have already constructed.

Experiences with the common cold and flu may well shape, starting in early childhood, the development of a general intuitive theory of infectious disease that is then used to make inferences about both familiar and novel diseases. This would help to account for the many similarities reported here between children's explanations of flu and AIDS. With age, knowledge of different diseases likely becomes more differentiated as children encounter new disease-specific information and "fine tune" their theory of each specific disease. Because so many children in our sample referred to generic "germs" rather than "viruses" in talking about flu whereas they commanded a more advanced biological vocabulary in discussing AIDS, we can speculate that children stick with the vague contagion theory of flu they learned early in childhood because they are exposed to very little new information about flu thereafter.

These ideas need to be tested, of course, in future research—longitudinal research that traces similarities and differences and mutual interactions between children's conceptions of different diseases as they get older. Such research should also investigate socialization influences such as culture, parent education, race/ethnicity, socioeconomic status, and gender, as well as experiential factors such as personal experiences with disease, everyday conversations with parents about disease, learning through the media, and the like.

To date, age is by far the most consistent predictor of children's knowledge and understanding of infectious diseases. Studies of children's thinking about HIV/AIDS have revealed little sign of race/ethnicity, gender, and SES differences [14, 30], although parent education has been linked to more viral knowledge and more willingness to interact with people who have AIDS [30] as well as to greater knowledge of flu [21]. Interestingly, Hispanic ethnicity, which has been linked to lower levels of understanding of respiratory illnesses among children [25], possibly because of the prevalence of cold weather folk beliefs in Hispanic samples, was associated with greater knowledge and understanding of flu

among minority, primarily Mexican-American, children than among Euro-American children in a study that controlled for parent education and family income level [21]. Clearly more remains to be learned about both sociocultural and individual influences.

Limitations

The findings of this study pertain to whatever children themselves meant by "flu" or "AIDS" and to the criteria we used to define adequate knowledge and understanding. Our interview protocol may have encouraged children to think in more advanced ways than they might have otherwise by asking them, if they did not mention internalization spontaneously for example, whether something gets in the body that makes people get sick and by probing them to explain their answers in more detail. At the same time, open-ended questions demand more cognitive and linguistic competence than closed-ended questions and tend to underestimate what children, especially younger children, know [29].

Finally, because the data were collected in 1992 in the southwestern United States, we cannot be sure whether the findings would hold true today and in other sociocultural contexts. Although flu seasons vary in scope and severity, they recur yearly, whereas AIDS does not recur yearly and is also a quite different disease today than it was in 1992—less lethal, more chronic and manageable. AIDS also receives far less attention in the media and in schools today, so children today are probably not as aware or afraid of it as children in 1992 were. Children today do have more direct access to information about diseases through the media than they did during the AIDS epidemic. However, as the COVID-19 pandemic has illustrated, they also have more access to myths, conspiracy theories, and misinformation [34], so it is hard to predict whether the current media environment is likely to make them more or less knowledgeable about infectious diseases. Most importantly, research has shown that the dominant influences on children's conceptions of disease appear to be the neurological and cognitive-developmental changes that come with age and that enable older children to better absorb and organize information about any number of topics. These basic developmental changes are likely make children today developmentally similar to children in the past, outweighing the sociocultural and demographic influences that might make them different [14,21]. Moreover, although children are very capable of learning about disease causality if they are taught about it [1-2,4,41-42], health education about disease continues to be very limited at the elementary school level [6].

Conclusions and Implications

The findings reveal that many children have acquired by ages 8 or 9, and elaborate with age, basic conceptual understanding and knowledge of how the infectious diseases influenza and AIDS are caught and make people sick. At the same time, the findings indicate that thinking about flu in the 1990s, when AIDS had emerged as a major health

threat, was more advanced in some respects among the youngest children we interviewed than thinking about AIDS, but was in other senses less biologically sophisticated. The implications of this research for parents, educators, and health professionals interested in helping children understand and protect themselves from new health threats like COVID-19 are clear.

The findings point to the value of assisting children in constructing more complete and accurate theories by filling gaps in their causal accounts—for example, by teaching them about disease-specific germs and viruses; challenging their misconceptions about the role of cold air in colds and flu; educating them about how germs and viruses replicate and do damage inside the body and how the immune system mounts a vigorous defense against them; and helping them "connect the dots" in coherent causal stories linking risky contact with people who have a disease to internalization of a disease agent, invisible events inside the body, and observable symptoms. Even young children can acquire more sophisticated understandings of illnesses—and can as a result be motivated to adopt appropriate preventive behaviors—if they are given key causal information that helps them construct a coherent theory of how people get a disease [1-2,4-5,41-42]. By rigorously analyzing children's understandings and intuitive theories of illness, we will be in better position to help even young children elaborate them where they are vague or wrong so that they can better protect their health and that of others. The importance of doing so could not be clearer in the context of the COVID-19 pandemic. Even preschool and early elementary school children appear to be learning new things about contagious illness during the pandemic [43] and will likely be assisted in their learning by the fact that COVID-19 is more like colds and flu than AIDS is and therefore fits better with children's existing theories of infectious disease. Still, both children and adolescents need further help making sense of flu, colds, RSV, and COVID-19—all current threats to child health, all transmitted similarly (and more easily than HIV), all sharing similar symptoms, and yet each caused by its own viruses and very likely each subject to its own misconceptions [34-35].

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Funding Statement
Data collection and initial work on the data for this study were funded by the National Institute of Child Health and Human Development (grant number HD27472).

Acknowledgements:
My thanks go to many for their contributions: The original team led by Eileen Derenowski, Olga Durazo, Amy Maddock, Takayo Mukai, and Teresa Woods; Sarah Glaser for her work on the new intuitive theories coding system; and Freya Blackmore for help preparing the current manuscript.

Conflict of Interest Statement:
The author has no conflicts of interest to declare.

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