The Unique Developmental Considerations of Youth-Related Work Injuries

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Adolescents and young adults experience higher risks of occupational injuries and fatalities compared to adult workers. Consequently, understanding the risk and protective factors for young workers through a developmental lens is all the more compelling. This study describes the developmental processes of adolescence using a *bioecological* framework. It describes how factors such as neuromaturation, pubertal development, physical growth, and social contexts may place youth at greater risk of injury and other negative outcomes in the work environment. While the emphasis of the paper is on the developmental processes specific to adolescence, this is discussed in the larger contexts of macro forces such as policies, schools, and families. Implications of developmental factors on work-based practices and policies are also discussed. *Key words*: adolescent; young adult; occupational health; policy, public health; epidemiology; developmental science.

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INTRODUCTION

With over six million adolescent workers in the US, work-related injuries and deaths among youth impact all levels of society.[1] In addition to health consequences, work-related injuries represent a substantial economic burden. The National Safety Council estimated that in 2007 work-related injuries cost $175.3 billion in medical care, loss of productivity, and wages.[2] One study estimated that youth-related work injuries accounted for $5 billion, or 3.9% of all workplace injury costs in the United States.[3] To the individual and family, injuries may develop into chronic disabilities, associated with years of discomfort as well as physical and mental health problems. Although occupational injuries and deaths have declined in the past few decades, exposure to hazardous work environments remains a public health problem. Despite regulations and measures to protect young workers from harm in the work environment, young workers continue to be of particular concern because they show an increased risk of work-related health injuries compared to adults.[4] For the purposes of this paper, young worker and youth refer to those aged 10 to 24 years.

According to data from the National Longitudinal Survey of Youth, 41% of high school freshman and 87% of high school seniors worked during the school year or the summer following their senior year in the US.[5] During the developmental period between early adolescence (10 to 14 years), late adolescence (15 to 19 years), and young adulthood (20 to 24 years), key normative transitions take place, including cognitive, physical, and social changes. A developmental framework helps us better understand these unique biological and psychological factors that put youth at greater risk of injury compared with adults. Because the majority of American adolescents will have worked before finishing high school, addressing their specific needs is critical in producing a healthier adult workforce.

This paper describes the current landscape of work-related risk among youth, stressing fatal and nonfatal injuries and potential risk factors that contribute to adverse outcomes. The paper emphasizes the developmental processes of adolescence and young adulthood using a *bioecological* framework.[6] It describes how these factors may put youth at greater risk of injury and other negative outcomes in the work environment. The emphasis of the paper is on the developmental processes specific to young workers, but this is discussed in the larger contexts of macro forces such as policies, schools, and families. The goals of the paper are to: (1) describe the cognitive, physiological, and social development issues unique to youth; (2) understand how these issues put working youth at increased risk of injury or other negative health outcomes; and (3) understand the implications of these developmental factors for work-based practices.

WHY A DEVELOPMENTAL APPROACH?

Differences in developmental factors put youth at increased risk compared with adults. Young workers have the highest rates of work-related injury of any group in the workforce,[7] resulting in an estimated 100,000 injuries per year in the US.[8] This fact, coupled with the realization that over 80% of US adolescents will have worked during their high school years[9] makes understanding the epidemiology of their work-related injuries all the more compelling.

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Outside of agriculture, the majority of youth who work do so in the service and retail sectors. Working conditions place young workers in environments where tool design, working surface height, and equipment dimensions are often designed for adults. Furthermore, adolescent work is often characterized by a lack of training, low pay, little supervision, and low job security, placing youth in hazardous environments where they sometimes need to make decisions for which they do not yet have the cognitive capacity. Young workers are asked to perform tasks outside their usual work assignments, such as driving motor vehicles or using equipment, without receiving formal training. In addition, they may be unfamiliar with work requirements and safety protocols; in instances where there is an authority figure such as a supervisor, young workers may not be aware of their legal rights or possess a command of negotiation skills.

With the understanding that development is a bidirectional process, that is, development and context influence the likelihood of injuries, but injuries may also impact the development of youth, prevention of injuries becomes all the more important. Experiences associated with developmental changes combined with workplace environments and inappropriate expectations place young workers at risk for injuries. From the viewpoint of the adolescent, injuries at work may result in lower school attendance and lower school achievement, and impact physical and psychological well-being. Studies addressing developmentally appropriate tasks have been underresearched. Even among working adults, the research surrounding behavioral health outcomes, such as job injuries, has been limited. However, while data and research on the interrelationships among developmental risks and youth employment are lacking, it is important to highlight what we do know so as to create safe working environments for young people.

The following section highlights youth work and experiences of fatal and nonfatal injuries.

YOUTH WORK: PREDICTORS OF FATAL AND NONFATAL INJURIES

Fatal Injuries

Runyon notes that there are approximately 70 fatal injuries among adolescent workers per year, which translates to 5.11 per 100,000 workers per year; however, this may be an underestimate.[10] Additionally, as Runyon notes, whether this represents an increase over the previous decade is difficult to determine due to the lack of accurate denominator data or data on numbers of young workers.[10] However, Loomis, Bena, and Bailer, when examining trends in fatal adolescent injuries between 1980 and 1996, found that there was a decline of 3% per year of both unintentional fatalities and occupational deaths and that the decline was steeper for younger (7% per year) when compared with older workers (2 to 3% per year).[11]

While the exact trends can be debated, what we do know is that when controlling for gender disparities in employment, gender is a predictor in work-related fatalities. Adolescent males are significantly more likely to be involved with fatal as well as nonfatal injuries. For example, in the analysis of Oregon worker compensation claims data, McCall, Horowitz, and Carr reported that while the overall claims rate for adolescent injuries was 134.2 per 100,000, males had more than twice the rate compared to females.[12]

Additionally, characteristics of workplace environments and industry also place adolescents at greater risk. Agriculture and construction are the two primary occupations where adolescent fatalities occur. In an analysis of construction fatalities among adolescent workers (n = 76), Suruda, Philips, Lillquist, and Sesek found that compared with adults who died, adolescents were more likely to have been employed by nonunion firms (odds ratio [OR], 4.96), smaller firms with under 11 employees (OR, 1.72), and have employers who had been cited for safety violations by the US Occupational Safety and Health Administration (OSHA) (OR, 1.62). The authors conclude that half of all of these deaths occurred in direct violation of child labor regulations.[13]

While there are higher rates of work fatalities reported among sixteen- to seventeen-year old males, there are relatively few fatal work injuries among those 15 years old and younger. Factors that explain differences between these two age groups include: fewer hours worked, less complex work tasks, lower likelihood to combine work with substance use, and less physically demanding work among fifteen-year olds compared to sixteen- to seventeen-year olds.[10] Thus, it becomes difficult to disaggregate the relationship between fatal work injuries and neuromaturation by looking at the epidemiologic data alone.

Nonfatal Occupational Injuries

There is an extensive literature on the factors associated with nonfatal work injuries. In a recent study of the relationships between socioeconomic status (SES) and work-related injuries among youth, with lower SES backgrounds related to situations in which youth work to support their family, Rauscher and Meyers found that as social status increases, work-related injuries decrease.[14] Moreover, Breslin found that the educational level of the youths themselves was inversely correlated with work-related injury.[15] In this Canadian study, Breslin compared prevalence rates of work-related injury among those who were out of school to rates among peers currently employed; Breslin found that those who were in school were significantly less likely to sustain occupational injuries than their out-of-school peers.[15]

Moreover, the number of hours a young person works is associated with a number of health risk factors including substance use, sexual risk, and injuries. For example, findings from the National Longitudinal Study of Adolescent Health demonstrated a positive association among seventh- to twelfth-grade students who worked more than 20 hours per week with alcohol, tobacco, and marijuana use, as well as early sexual debut.[17] The number of hours worked per week has also consistently been associated with workplace injuries. In a study of middle-school children in Texas, Weller, Cooper, Tortoero, and colleagues found that 56% of sixth- to eighth-grade students reported working an average of 7.7 hours per week.[16] As the number of hours increased, so too did injury: those who worked more than 20 hours per week had more than two times greater likelihood of injury (OR, 2.4) when compared with peers who worked one to 10 hours per week. Runyan, Schulman, and Ta report that 39% of all adolescent workers work more than 20 hours in a typical week during the school year.[18] The relationship between numbers of hours worked, health risk behaviors such as substance use (both during and after work hours), and how these factors effect injuries should be explored further among youth.

A third factor associated with nonfatal work injuries relates to the type of work in which adolescents are employed as well as the types of tasks they are expected to undertake. Specifically, adolescents are disproportionately employed in industries where the risk of injury at every age is greater than average: fast food restaurants, grocery stores, agriculture, hospitals, and nursing homes. Many of these jobs are characterized by minimal training, limited supervision, low pay, and high job insecurity, which creates the conditions for young people to take risks that predispose them to injury. Specifically, Evenson et al. reported that perceived pressures on the pace of work and exposure to hazards, respectively, were positively associated with the types of injuries youth experienced.[19] For example, in the restaurant industry, youth are exposed to hot stoves, boiling grease, and machinery, all of which predispose them to injury, especially in the context of minimal supervision and training. While there is ample evidence that safety training is often lacking for youth workers, whether the training actually makes a difference is debatable. For example, in a systematic review of farm safety programs, DeRoo and Rautianen concluded that only three of the 25 studies considered behavioral impacts of the intervention, and further, those that did were sufficiently limited methodologically to preclude deducing impact.[20]

There are other factors associated with nonfatal injuries which are described in the literature, but the extent to which they improve our understanding of what contributes to youth workplace vulnerability is uncertain. For example, adolescents who work in both farm and nonfarm settings are more likely to be injured than those who work at only one type of job.[21] So too, we know from a 2006 study that there are ethnic and racial disparities among youth who are injured at the workplace, with both Latino and Black youth being more likely to sustain injury compared to their White peers.[22] As the authors of that study note, however, whether this is a function of minority youth working more hours per week, the type of jobs in which minority youth are employed, or other factors is uncertain. How to use this information to reduce work hazards for youth is equally unclear.

TABLE 1 Prevalence of Injury by Type of Injury among Workers Aged 17 years and Under, United States

Injury or Illness Type	Percent of Cases in Workers 17 Years and Under
Sprains and strains	32%
Heat burns	15%
Cuts, lacerations	14%
Bruises, contusions	9%
Fractures	8%
Other	22%

Table 1 summarizes the types of injuries adolescents sustain at work.[23]

UNDERSTANDING WORK-RELATED HEALTH RISKS THROUGH A DEVELOPMENTAL LENS

Adolescent development is an interactive process between individual pubertal maturation and the multiple contexts in which adolescents live, including home, school, and work. The present study used Bronfenbrenner's bioecological framework to conceptualize the multiple-level influences that may interact or contribute to work-related injuries, from the most proximal, including biological processes, to more distal factors, such as neighborhoods, labor laws, and policies.[6] The framework operates under the assumption that youth injury and death result from macro-level forces that may mediate or buffer biophysiological processes. Interactions between parents, teachers, and peers are proximal processes that act as the primary engines of development, directly and profoundly shaping youth experiences. This framework views work-related injuries as the consequence of a complex network of interactions. Injuries, therefore, have multiple causes and affects for diverse people and diverse reasons.

Young Worker Individual Processes

Pubertal development. Pubertal development is characterized by rapid linear growth and biophysical changes; such developments are influenced by a complex interplay between neurohormonal shifts and the develop-

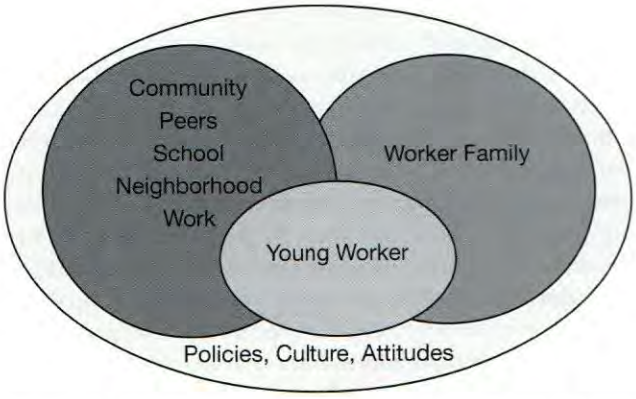

Figure 1—Ecological model of young worker injuries, adapted from Bronfenbrenner.[6]

ment of secondary sex characteristics. Additionally, though less visibly, pubertal processes result in maturation of all organ systems, including the musculoskeletal and cardiovascular systems. Given rapid linear growth, for example, joint instability during these years predisposes the maturing adolescent to injury. Also, the maturational changes of the brain, especially the prefrontal cortex, are extremely important in regulating emotional response and reactivity.

Neurohormonal shifts are associated with depression and drug and alcohol use.[24–26] Depression typically emerges after puberty with incidence increasing throughout the second decade of life, especially among post-pubescent females; a similar pattern emerges for substance abuse.[27] Likewise, based on human and animal models, the neurodevelopmental changes that youth experience have been linked with a greater inclination for thrill-seeking that creates high-intensity feelings.[28] For example, sensation-seeking, a trait characterized by the desire to seek out "varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, financial risks for the sake of such experiences" increases during the adolescent years, and plateaus and decreases in adulthood.[26–29] Even after adjusting for age, sensation-seeking is directly associated with pubertal development among adolescents.[26] All of these changes can predispose a young person to increased probability of work-related injury.

Furthermore, hormonal levels have been demonstrated to be associated with behavior and reactivity. For example, higher levels of testosterone among adolescent males is linked with greater frustration, less tolerance, and increased reactivity, predisposing such individuals to injury at the work place.[30] While there have been no studies that we know of that directly link testosterone plasma levels with adolescent work-related injuries, personality traits such as rebelliousness and impulsivity have been implicated in occupational injuries.[31] What is important vis à vis the workplace is that pubertal maturation occurs within a wide range of ages (that is, eight to 16 years for females and nine to 17 for males), posing challenges for age-based work policies.

Moreover, adolescence is characterized by emerging independence and autonomy, and teenagers assume a range of responsibilities, including school, work, and family. In taking on all of these activities, adolescents tend to stay up later. This is reinforced by chronobiological shifts. For example, Dahl, Trubnick, al-Shabbout, and Ryan studied the interrelationship between puberty and circadian rhythms, and found that around mid-puberty the rhythm begins to shift toward more nocturnal wakefulness and a later bedtime.[32] But while adolescents may regularly go to sleep later for a number of social and biological reasons, this is not balanced by sleeping later the following morning: the deficit caused by late night wakefulness is not compensated for. Therefore, many adolescents tend to sleep fewer hours even though their physiologic demand for sleep is greater than it was in early childhood.[33,34] Consequently, without sufficient catch-up sleep, daytime sleepiness is not uncommon. Studies on sleep deprivation are linked to decreased work functioning and capacity, and falling asleep while driving is also indicated as a source of motor vehicle injuries and crashes among adolescents.[35,36] Under such conditions, youths' risks of injury increase.[37,38]

Further complicating the maturation process is the fact that, as will be discussed below, brain development is even more prolonged, especially in those areas of the brain that control judgment.

Physical and physiological development. The second decade of life is a time in which 15 to 20 percent of an individual's height is acquired. It is, in fact, the only time in the life course that the rate of growth is accelerating. Half of this growth occurs in a span of two years. Females and males reach their peak height velocity at ages 12 years and 14 years, respectively;[39] however, for males, linear growth may continue into late adolescence or even early adulthood. As a result of rapid growth, teenagers are more vulnerable to injuries to ligaments and bone growth plates. Furthermore, back strains represent a high proportion of work-related injuries that cause young people to miss work.[40]

Research has demonstrated that the size of equipment and machinery at workplaces may be inappropriate for children and adolescents as most are designed for adults. For example, an unpublished study conducted by the Consumer Product Safety Commission report that young, short, and lightweight operators of ride-on mowers were more likely to be injured than others.[41] Those with height less than 60 inches, weight less than 125 pounds, or age less than 15 years were at an increased risk of injury. Research surrounding physical changes in the body is especially relevant in agricultural work, which accounts for the greatest number of work-related fatalities.[6,10,42]

Research suggests a positive correlation between body mass index and workplace injuries among adult manufacturing employees.[43] While this association has not been studied formally among adolescents, the trend during adolescence towards being overweight raises concern. The prevalence of overweight doubled among children six to 11 years of age and tripled among those 12 to 17 years of age between the second National Health and Nutrition Examination Survey (NHANES) (1976-1980) and the most recent NHANES survey, conducted in 1999 and 2000.[44] The interrelationship between overweight and work injury is an area that warrants future research.

Neurodevelopment. While a generation ago it was believed that brain development ceased when the sutures of the skull fused (at about the age of three years), rapid progress in new neuroimaging techniques has radically changed our understanding of brain growth and development over the past 20 years. Casey, Getz, and Galvan[45] and Giedd[46] provide in-depth discussions of adolescent brain development, and we now know that neuromaturation continues changing well in to the third decade of life.

Specifically, the prefrontal cortex appears to be the last part of the brain to fully mature and that process is not completed until the early twenties or beyond.[26,45-47] This is the area of the brain responsible for executive functions: emotional regulation, impulse control, and complex reasoning, including moral reasoning—skills critical to dealing with the complexities of the workplace. Moreover, as the prefrontal cortex develops, improvements in executive functioning are also fine-tuned, including understanding future risks and impulsive actions: young adults are able to better assess and react to risks.[45] Additionally, as the prefrontal cortex matures, so too does emotional regulation as well as the ability to plan and to bridge affective and cognitive reasoning. With this area of the brain still maturing during the teenage years, it is not surprising that external influences (whether it be peers or a supervisor), poor impulse regulation, and failure to take into consideration the full range of options available before acting may all be manifested in the workplace.

Neuromaturation is all the more deceptive since more often than not it takes place within a body that appears physically mature; that is, young people have experienced their peak height velocity and physical growth. Thus, it is not surprising that adolescent males exhibit the highest rates of occupational injuries, perhaps because they are given adult responsibilities based on their physical appearance while lacking adult decision-making skills.[48,49]

School, Peers, and Work

Outside of the home, school is the primary socializing environment for adolescents; consequently, peers and teachers greatly contribute to adolescent social and cognitive development. Although adolescents are sleeping later as they get older, the beginning of a school day tends to start earlier as teenagers move on from middle school to high school. Because many US adolescents are balancing education, employment, and perhaps extracurricular activities such as sports, it is not surprising that the amount of sleep they get decreases at just the time when their sleep demands increase. Students who work more than 20 hours per week stay up later, sleep fewer hours per night, experience daytime sleepiness, and have difficulty staying awake in school. Moreover, working more than 20 hours per week has been shown to be associated with increased use of stimulants such as caffeine and cigarettes.[50]

Furthermore, adolescence is a period in which close friendships are formed, and studies suggest that relationships among peers influence psychosocial and behavioral development. For example, Prinstein found that an adolescent's substance use, violence, and suicidal behavior were related to his or her friends' substance use, deviance, and suicidal behaviors.[51] Friends' prosocial behavior was also inversely correlated with adolescent violence and substance use. While there has been little to no research on the connection between peer relationships and occupational injuries, research has demonstrated that peers influence the behavioral development and choices of youth, including use of tobacco, alcohol, and marijuana, as well sexual activity.[52] For example, findings indicate that substance abuse can be an outcome of friendship influence and selection processes,[53] and that on-the-job substance use is a major predictor of work injuries due primarily to psychomotor and cognitive impairments.[31] Additionally, research from the National Automotive Safety Council indicates that younger adolescents are likely to take more driving risks as the number of peers in the car increases. Specifically, using simulated driving tests, teens less than 16 years old were more likely to drive through warning lights and crash than when they were alone. The influence of peers on driving behavior diminishes starting at 17 and by young adulthood, no influence was noted.[54] Further research is needed concerning peer influences in order to strengthen efforts in understanding adolescent injuries in the workforce.

POLICY MATTERS

When we turn to factors that have clearly been shown to exacerbate (or conversely, to minimize) workplace injury for youth, a number of factors inherent in the workplace itself begin to emerge. The 1938 Fair Labor Standards Act (FLSA) was established to limit the number of hours per week that those under 16 years of age can work and to limit the jobs that those under 18 years could pursue. Specifically, legislation banned 17 hazardous jobs, including logging and coal mining. Cur-

rently, despite 70 years of legislation, enforcement of this legislation is hampered by few inspectors, trivial penalties for infractions, and no impact evaluation.[10] The weight of evidence is quite strong that adolescents who work more than 20 hours per week during the school year have increased risk of injury as well as greater exposure to a host of health compromising behaviors, such as illicit substance use and precocious sexual behaviors.[17,41] In addition, those who are expected to complete tasks that are prohibited by FLSA are at increased risk for injury.[10,55] But participation in prohibited activities is only part of the problem. As Runyan et al. so graphically portray in the vignettes of three young workers who lost limbs as a result of workplace injuries, the use of dangerous equipment without proper training and adult supervision also predisposes youth to harm.[18]

Another policy consideration that appears related to adolescent work injury is the family farm exemption from federal child labor laws. Specifically, when Marlenga, Berg, Linneman, et al. looked at nearly 1200 farm injuries among children in the US and Canada, a quarter of the cases involved family members and a third involved children under 16 years of age.[56] An additional 36% of the injuries involved sixteen- to seventeen-year olds who were performing prohibited tasks under the Hazardous Occupation Orders. The limitations of voluntary farm guidelines was also underscored by Zentner, Berg, Pickett, and Marlenga, who found a very weak intercorrelation between farm parents' perceptions of work-related risk regarding their children and their application of the North American Guidelines for Children's Agricultural Tasks (NAGCAT).[56]

RECOMMENDATIONS AND FUTURE DIRECTIONS

The bioecological framework presented, by applying an established framework to the risk of occupational injury and fatalities for youth workers, provides a new perspective on this issue. Because most workers enter the labor force during their adolescent years and are at an increased risk for injuries, prevention efforts should target this population. Young workers experience unique developmental milestones, and they need proper training regarding the risks of the work environment. Tailoring injury prevention strategies to the cognitive, social, and physical development needs of young workers will be of utmost importance in the coming years as greater knowledge in these fields emerge. Based on the bioecological framework, a multiple systems approach should be taken in addressing work injuries. Key recommendations to help reduce the risk of injuries for adolescents in the workplace include the following:

1. Provide adequate training for young workers. Prevention efforts should be available at the workplace with increased training by employers to help adolescents successfully perform tasks. However, schools, parents, and teachers should also play a role in alleviating adolescent work injuries and be held accountable for young workers' safety. Health and safety training should be available in schools through health or vocational classes, and should serve as a source of information for young people. Because neuromaturation may not be completed until early adulthood, youth need careful supervision and training.
2. Educate young workers on work requirements, functions, activities, and legal rights. Parents, schools, and supervisors should educate young workers on their rights, roles, and responsibilities in the work place. Youth should be informed of the risks and benefits associated with working, age requirements for tasks, and rules established by FLSA.
3. Educate work supervisors, parents, and schools on developmentally appropriate activities. Employers, parents, and schools should be aware of developmentally appropriate tasks for adolescents, making sure that work is designed to minimize physical hazards, heavy machinery or equipment use, and boredom, while at the same time enhancing social, emotional, and cognitive development. So too, employers need to also be vigilant about substance abuse both on-the-job as well as before youth arrive at work.
4. Monitor number of hours worked and other extracurricular activities. Parents should regulate adolescent activities, including number of hours worked and sleep time. The number of hours an adolescent is allowed to work needs to be limited and monitored.
5. In order to identify developmentally appropriate tasks, studies should be conducted to directly link developmental measures with behavioral outcomes such as injury. Research is needed to link our understanding of neuroregulatory systems and the identification of developmentally appropriate work tasks. Furthermore, additional funding should be available for understanding the relationship between BMI and workplace injuries, possibly allowing the workplace to serve as a setting that can simultaneously address problems with overweight as well as occupational injuries.

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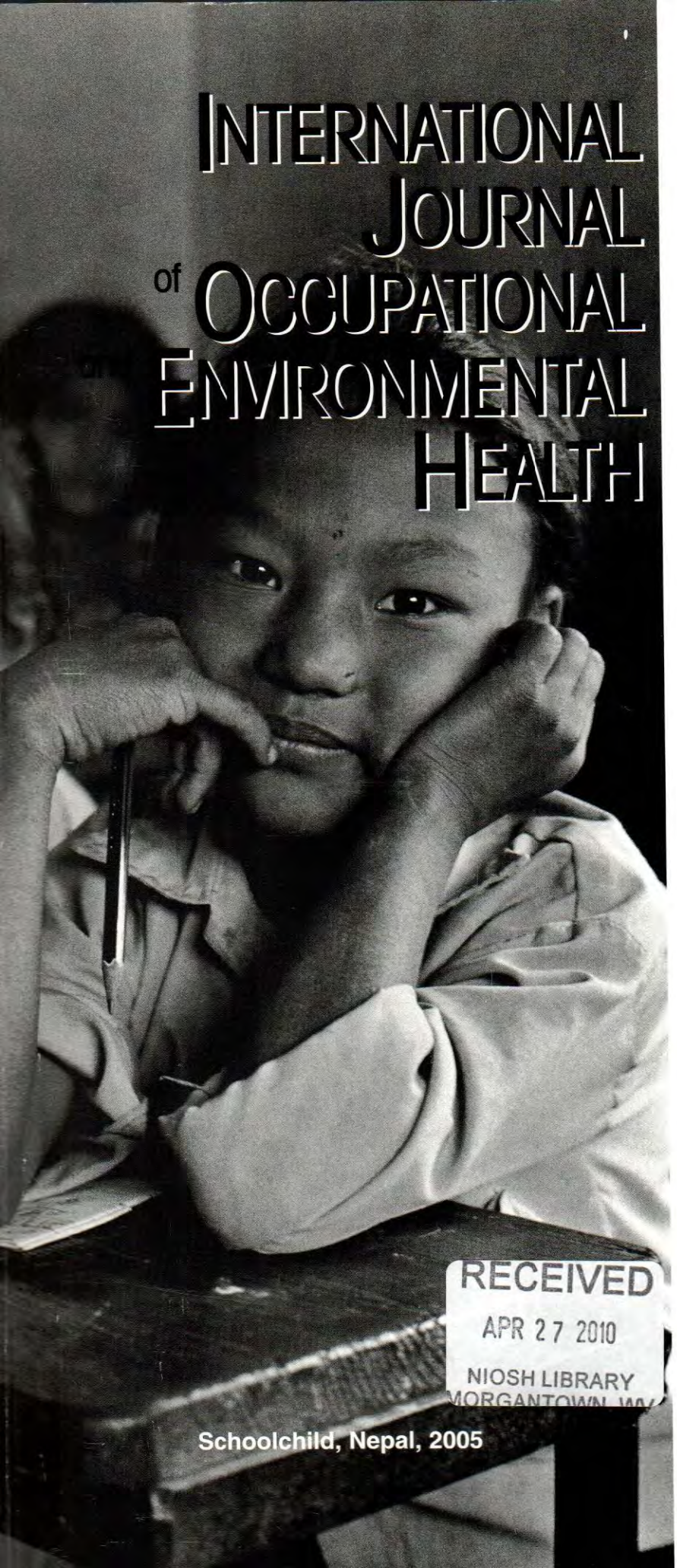

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