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ORIGINAL RESEARCH

Children Crossing Streets: The Cognitive Task of Pedestrians Across Nations

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Abstract

BACKGROUND About 100,000 children die worldwide in pedestrian crashes, more than 90% of whom live in low- and middle-income countries (LMICs). However, most existing research on children's ability to cross the street is conducted in high-income countries (HICs).

OBJECTIVE The present study discusses 4 ways pedestrian behavior in LMICs differs from that in HICs, influencing both children's ability to cross streets safely and adult efforts to train children in pedestrian safety.

FINDINGS First, in many LMICs one cannot simply wait for a traffic gap that is large enough to permit crossing at a typical walking pace. Instead, pedestrians must enter traffic gaps they deem large enough to permit the oncoming driver to stop, slow, or swerve around them. Second, decisions in LMICs must be made very quickly to maximize safety. In many cases, pedestrians must anticipate how oncoming drivers will behave as a crossing is initiated. Third, multilane LMIC crossings sometimes involve separated decisions to cross each lane and then evaluate safety in the middle of the roadway rather than making a single decision to cross the entire span within a safe traffic gap. Last, children's short stature may substantially influence behavior in LMIC settings. When gaps are small and open spaces limited, the ability to see over oncoming vehicles and perceive them approaching, including how spread they are and at what speeds they are traveling, offers a distinct advantage to the taller pedestrian

CONCLUSIONS Taken together, it is concluded that safe child pedestrian engagement in LMICs is more complex, and may require more developed cognitive skill, than safe child pedestrian engagement in HICs.

KEY WORDS pedestrian, safety, injury, cognition, child development

Global Burden of Disease data estimate about 100,000 children die worldwide in pedestrian crashes.[1] A disproportionate number of those deaths (>90%) occur in low- and middle-income countries (LMICs); about 62% of the world's children live in LMICs.[1,2] Almost all existing research studying children's ability to cross the street, however, has been conducted in Western Europe and North America, primarily in the United Kingdom and United States.[2,3] In nonsignalized high-income country (HIC) locations, which present particularly significant risk in middle childhood,[4,5] traffic is generally moderately dense.[6,7] Children being taught to cross streets are instructed to watch traffic and identify a gap that is large enough to permit their crossing safely all lanes of traffic before the arrival of oncoming vehicles in any of the lanes.[2,8,9] Among children, this decision relies on still-developing cognitive skill to judge the speeds and distances of oncoming traffic, plus to estimate the time it will take the child to cross the lanes of traffic.[10-12] Developmental psychologists suggest such cognitive skill emerges in typically developing children around the age of 10, and may develop

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earlier—perhaps at age 7 or 8—with sufficient training and practice in simulated or real environments.[8,9]

In much of the world, however, anecdotal evidence suggests that traffic is more than "moderately dense,"[6,7] traffic gaps are often not large enough to permit crossing multiple lanes at the same time, and pedestrian crossings require far more complex cognitive processing than is true in high-income countries. In urban areas of many LMICs,* traffic is much denser and pedestrian crossings require substantially more cognitive skill, which may not be present in young children.[8,9] Not coincidentally, these also are countries estimated by Global Burden of Disease data to have much higher rates of pedestrian injury deaths and injuries, both among the overall population and among children (Figure 1).[1]

To cross the street in LMICs, pedestrians must still judge the speed and distance of oncoming cars, just as they do in HICs. Stated in terms of Gibsonian theory,[8] children worldwide must learn to judge the affordance of an approaching traffic gap. They must decide whether a particular traffic gap will allow them to safely cross the road without harm. They must also judge the distance across a lane of traffic and the time it will take to propel themselves across that distance. However, unlike the situation researchers have studied in HICs, pedestrians in LMICs face a more complex and more challenging task. The present study identifies 4 significant ways that pedestrian behavior in LMICs differs from pedestrian behavior in HICs, where the vast majority of empirical research has been conducted; these differences affect greatly children's ability to cross streets and our ability to train children in pedestrian safety.

First, children in some LMIC locations cannot simply wait for a traffic gap that is large enough to permit their crossing at a typical walking pace; anecdotal evidence of such situations has been published from several countries, including Thailand,[13] Vietnam,[14] Egypt,[15] and India.[16] Such waiting would be unrealistic and often endless given the density of traffic. Instead, pedestrians in LMICs must follow local practice, which often involves entering traffic gaps they deem large enough to permit the oncoming driver to stop, slow, or swerve around them. Cognitively, this judgment involves many of the same components of crossing in HICs: Speeds and distances must be perceived and computed. However, additional cognitive load emerges. For one, the type of approaching vehicle must be considered. Given their weight and size, trucks and buses take longer to stop than cars.[17] Motorcycles, scooters, and bicycles can swerve within a lane but other vehicles cannot. Further, the perspective of the driver must be considered: Pedestrians must consider whether the driver is attending to the situation and whether the driver will have time and motivation to react appropriately. Published anecdotes document the use of eye contact and visual signals that adult pedestrians provide oncoming drivers in some LMIC locations.[13,14]

Second, to maximize safety, decisions in LMICs must be made very quickly—even more quickly than the roughly 1-second window reported among adults and the 1.25-second window among 7- to 8-year-old children in HICs.[3] Scholars report some tendency for adult pedestrians in HICs to enter near lanes of 2-lane roads while a vehicle is still passing the far lane.[18,19] Such "anticipations" are efficient and increase the size of a crossable gap. In LMICs this need is amplified, and anecdotal observations suggest it is common for adults in many LMICs to enter lanes immediately after a vehicle has passed, signaling their intention to cross early—sometimes verbally or through eye contact—and essentially pivoting into a tight gap to "protect" their position in the lane as soon as the rear of a vehicle passes.[13-16] Children in HICs struggle to anticipate future gaps, instead processing gaps as they appear[20,21]; such inefficiency would increase children's risk dramatically in LMIC pedestrian settings.

A third distinction between pedestrian crossings in LMICs versus HICs is that the pedestrian task in multilane LMIC roads is not necessarily a single decision, as it might be in most HIC settings. Instead, pedestrians in multilane LMIC roadways may cross a single lane and then wait in between lanes and amid traffic before crossing the next lane.[13-16] This increases risk to pedestrians, of course, as they are exposed to moving traffic while waiting for a passable gap to emerge in the subsequent lane. It also might encourage risk taking and selection of very tight gaps to minimize exposure to oncoming traffic while standing in the road. Children with inefficient decision-making

*The term *low- and middle-income countries* is used here to signify countries and geographic areas where traffic patterns are dense, pedestrian activity is complex, and street environments are somewhat chaotic. The author acknowledges this labeling is somewhat of a generalization, as such traffic patterns are present in many low- and middle-income countries but not all. Such traffic patterns also are present in some high-income countries.

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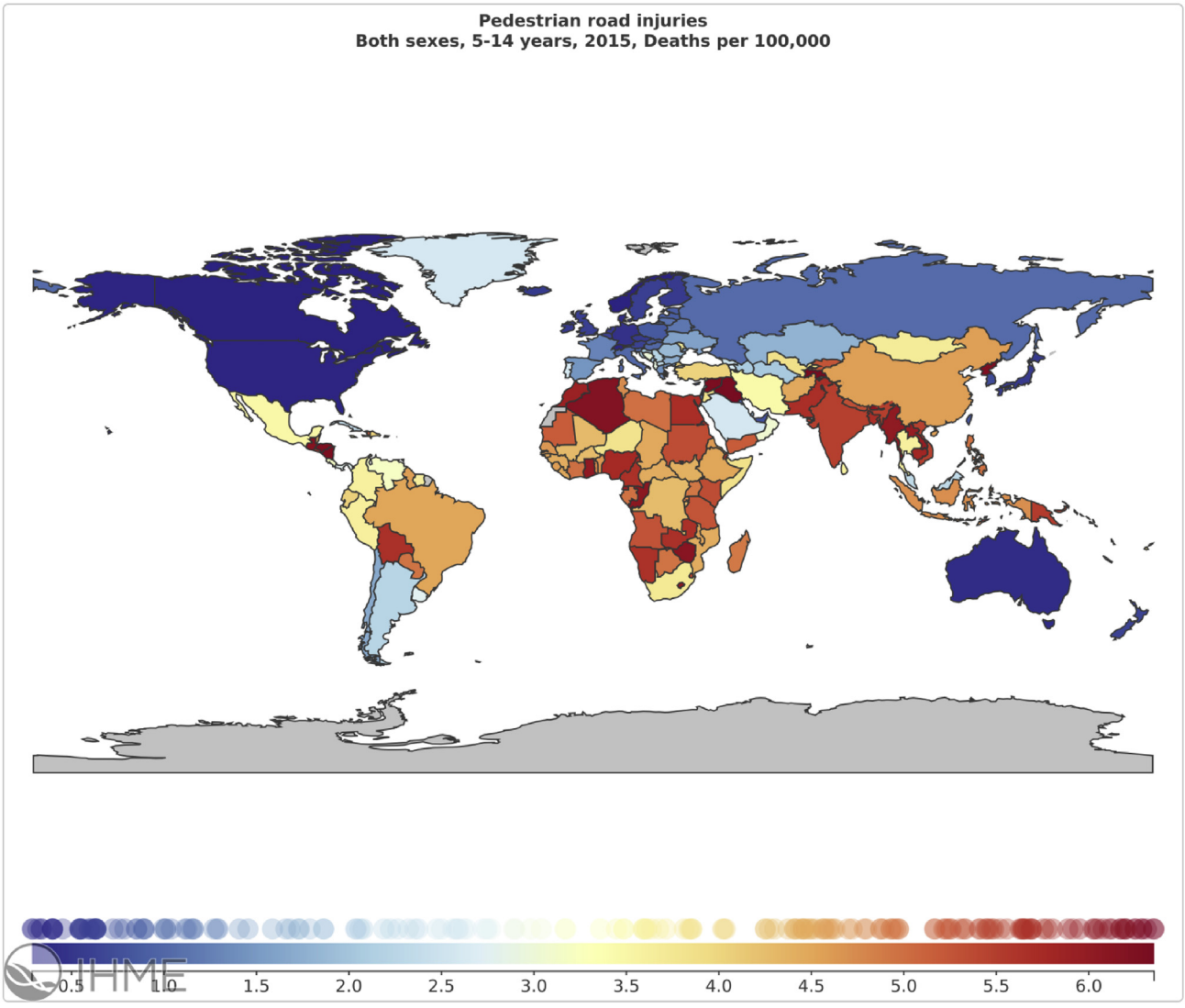

Figure 1. **Global pedestrian road injury rates, ages 5-14 years, based on Global Burden of Diseases 2015 data.**

skills would have substantially increased risk if they waited in traffic longer, trying to identify larger and safer gaps to cross within.

A final factor that influences child pedestrian injury risk in LMICs is the role of children's short stature. The inability to see over cars may limit decision-making capacity.[22] Just as adults have impeded views when large buses or trucks pass, children may not be able to see over passenger cars.[22] This is true in HICs also but represents a lesser impediment because traffic is less dense, creating larger gaps between vehicles that permit unoccluded vision of oncoming traffic. When gaps are small and open spaces limited, the ability to see over oncoming vehicles and determine what vehicles are approaching, how spread they are, and at what speeds they are traveling offers a distinct advantage to the pedestrian. Shorter children who lack this perspective are disadvantaged in planning pedestrian behavior.[22]

Taken together, available scientific evidence and anecdotal observations confirm what may seem rather obvious to those who have crossed streets in multiple different countries and cultures: safe child pedestrian engagement in LMICs is far more difficult, and requires more sophisticated

cognitive-perceptual skill, than safe child pedestrian engagement in HICs. Epidemiological data support this assertion, with child pedestrian rates in LMICs far surpassing those in HICs (Figure 1).[1]

Of course, the complex cognitive-perceptual task of crossing the street in LMIC is likely not the only reason for increased child pedestrian rates in LMICs compared with HICs. One might presume that walking on public streets is somewhat more common among children in LMICs than HICs, increasing exposure risk. Adult supervision of those children may also be less common. Built environments differ across countries and may contribute to pedestrian injury rates. Also relevant is the possibility that children's cognitive functioning may be affected by geo-specific factors in LMIC settings. Malnutrition,[23] exposure to environmental chemicals,[24,25] and chronic stress[26] are all documented to influence children's cognitive development and therefore may affect children's abilities to make safe decisions in traffic.

The American Academy of Pediatrics recommends children in the United States should not cross streets independently until at least 10 years of age.[27] Given the complexity of crossing streets in LMICs, we conclude children should not cross roads independently in LMICs until they are older than age 10 and that pedestrian safety training in LMICs might target children older than the typical HIC target of 7-8 years.

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