Unintentional injuries are the leading cause of death and disability for children beyond 1 year of age. It has been estimated that one in four children in the United States experience a medically attended injury each year, and that as much as 15% of all money spent on medical costs for youth ages 1 to 19 goes for treatment or rehabilitation related to unintentional injury. Increasing awareness of the personal and economic costs of unintentional injuries to youth, coupled with the realization that many injuries are preventable, have resulted in greater efforts to understand how such injuries occur and to devise ways to prevent these events from happening.

Epidemiological research reveals that many injuries to youth happen during activities that would be considered normative and age appropriate. For example, bicycling related injuries have been estimated to result in 400,000 emergency room visits each year for children under 15 years of age, and to account for as many as 5% of all injury related hospital admissions for children in Canada. Drowning ranks second as a cause of unintentional injury death among Canadians from birth through 24 years of age, with over 6% of all youth who die of injury related causes drowning. Fall related injuries are a leading cause of hospitalization for youth, accounting for more than 25% of all injury related hospitalizations. Furthermore, more recently a variety of other popular recreational activities have been found to pose significant threat of injury for young people, including: in-line skating, and outdoor frisbee games, as well as those involved in skateboarding,悬崖跳, and sledding. The picture that emerges from these data is that children are often at risk of unintentional injuries when engaging in activities that provide for other health benefits, serve as an important basis of social interaction with peers, and that most parents would encourage them to pursue. Efforts to manage injury risk for these activities therefore has turned to product design and environmental modifications, with a primary focus on the development and marketing of safety gear to reduce injury risk during these activities.

A number of studies have documented the efficacy of at least some safety gear to reduce the incidence and/or severity of certain types of injuries among youth. For example, bicycle helmet usage has been shown to reduce the risk of head trauma by as much as 80% and wrist guards, elbow and knee pads, and helmets substantially moderate injury risk for in-line skaters. The proven effectiveness of safety gear has resulted in widespread publicity and targeted interventions to convince parents and youth to utilize such gear. There has been little consideration given, however, to the impact these messages have on parents’ and children’s perceptions of injury risk. Specifically, what if such messages lead parents to assume that injuries are completely preventable when safety gear is worn, which results in parents having greater tolerance for children’s risk taking? This is the premise behind “risk compensation” theory, and the question addressed in the present study.

In general terms, risk compensation refers to the notion that in reaction to environmental or product design changes that serve to decrease injury risk individuals will behave in ways that increase risk of injury (see Hedlund for a full elaboration of the theory). Hence, the development of airbags that automatically inflate upon car impact with another vehicle will presumably result in more “risky” driving behavior because the driver believes himself or herself to be protected from injury due to the airbags (see Peterson et al). Not surprisingly, introduction of the notion of risk compensation has created much controversy among professionals concerned with injury control and risk management, particularly those who favor product design and environmental modification as a primary means of curtailing injury risk. A number of investigators have criticized fundamental premises of risk compensation theory, as well as those outlined in risk homeostasis theory, which is a related theory that proposes that individuals behave in ways to maintain a constant level of risk (see Evans, McKenna, and Wilde).
What evidence there is to support the notion of risk compensation comes mostly from studies of driving behavior (see Peterson et al.,24 Potvin et al.,25 Simonet and Wilde,26 and Streff and Geller27). In addition, there is some evidence in the area of product safety that is consistent with what one would predict based on risk compensation theory. For example, Viscusi and Cavallo examined the effects of cigarette lighter safety mechanisms in the households of families having children.28 They found that after the introduction of the safety mechanisms on lighters, parents reduced precautions with respect to lighters and fire safety (see also Viscusi and Cavallo26).

Building on these few studies involving parents, the purpose of the present study was to examine risk compensation theory as it relates to parents’ judgments about school age children’s permissible risk taking in situations wearing or not wearing safety gear for each of seven common play activities (bicycling, swimming in a pool, in-line skating, sledding, jumping on a trampoline, climbing on a playground climber, and running while playing outside). The specific question addressed was whether safety gear influences what mothers think about their child’s risk of injury and results in greater permissible risk taking under safety gear, as compared to no gear, conditions. Additional factors that were explored as possibly relating to permissible risk taking included the child’s level of experience with the activity (see Johansson20) and the parent’s belief about the efficacy of the gear to prevent injury (see Viscusi and Cavallo25).

### METHODS

#### Subjects

Participants included 54 mothers having a child in the 7 to 9 age range, with an equal number (nine) of males and females at 7, 8, and 9 years. These participants were randomly selected from the database of the Child Development Research Unit at the University of Guelph which comprises a list of families in the Guelph and surrounding areas who are interested in participating in research on child development. Families are recruited from the local hospital at the time of a child’s birth and they vary considerably in ethnic background, education level of parents, and economic status.

#### Materials

The questionnaire, delivered over the telephone as an interview, asked about seven different activities: swimming in a pool, climbing on a playground climber, sledding, bicycling, in-line skating, playing tag outside, and jumping on a trampoline. Each activity had both a non-safety gear condition and a safety gear condition for which the parent rated the extent of permissible risk taking by their child; the importance of using a within-subjects design has been confirmed in prior research on risk compensation theory.20 Table 1 provides a list of the safety gear and risk taking measure for each activity. For example, parents were asked to assume their child was ascending a climber at an indoor playground and report how high they would allow their child to climb if there was (and was not) thick safety padding on the floor beneath the climbing structure. The child’s experience with the activity was then rated on a six point Likert scale ranging from 1 “none/not much” to 6 “extensive”. Parents’ beliefs about the efficacy of the safety gear was rated on a six point Likert scale ranging from 1 “not effective at all” to 6 “completely effective” to prevent injuries.

#### Procedure

Subjects were contacted by phone and a future time for the 15 minute interview was arranged. Parents were asked to rate the extent of permissible risk taking by their child for both wearing and not wearing safety gear situations for each of the seven activities, with the no gear and gear conditions randomly ordered for each activity. If the no gear situation received a risk behavior rating less than the safety gear situation, then a question was asked to probe their reasons why (for example, “Can you help me understand why you would let your child go faster if he/she is wearing a helmet?”); these data were gathered to gain greater insight into how parents conceptualize injury risk and interpret safety gear as this relates to injury risk. Following the ratings of each activity, further questions were then asked to obtain ratings of the child’s experience with the activities and the parent’s beliefs about safety device efficacy.

### RESULTS

Risk compensation was measured by taking the difference between mothers’ ratings for the gear and no gear situations, with numbers exceeding zero indicating risk compensation.

#### Parents’ ratings of risk compensation

To assess for risk compensation, one sample t tests (with a Bonferroni correction applied) were conducted comparing the difference score for each activity to a score of 0 (that is, no difference). For each activity, averaged over boys’ and girls’ scores, the magnitude of the difference score significantly exceeded zero, indicating that risk compensation was operating (p<0.01). Furthermore, a multivariate analysis of variance (MANOVA) confirmed that there were no sex differences in the magnitude of risk compensation shown (p>0.05), although type of activity affected the amount of risk compensation, F(6, 364) = 15.44, p<0.01.

The average difference scores as a function of activity can be seen in Table 2. It is evident from these data that risk compensation was shown for all activities. However, one can also observe a great deal of variation in the magnitude of risk compensation, with some difference scores as low as 1.27 and others as large as 11.39. Follow up tests, with a Bonferroni correction applied, comparing between activities in the magnitude of risk compensation revealed significantly greater risk compensation for sledding and cycling than the other activities, and significantly less risk compensation for jumping on a trampoline and water play as compared to the other activities, with the magnitude of risk compensation shown for in-line skating, climbing, and running falling at intermediate levels between the two other activity groupings. Thus, wearing a life jacket resulted in greater permissible risk taking than not wearing one, but this difference score was small relative to

### Table 1 Activities, safety gear, and risk taking measures

<table>
<thead>
<tr>
<th>Activity</th>
<th>Safety gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Water play in a pool</td>
<td>Depth (feet)</td>
</tr>
<tr>
<td>(2) Sledding down a hill</td>
<td>Speed of travel (mph)</td>
</tr>
<tr>
<td>(3) Bicycling on a concrete surface</td>
<td>Speed of travel (mph)</td>
</tr>
<tr>
<td>(4) In-line skating on a concrete surface</td>
<td>Speed of travel (mph)</td>
</tr>
<tr>
<td>(5) Climbing at an indoor playground</td>
<td>Height on climber (feet)</td>
</tr>
<tr>
<td>(6) Jumping on an indoor trampoline</td>
<td>Height of trampoline (feet)</td>
</tr>
<tr>
<td>(7) Running outside</td>
<td>Speed of travel (mph)</td>
</tr>
</tbody>
</table>
mothers who believed their children had a high level of experience ratings showed the sort of systematic variation one would expect for the particular activities surveyed herein. Hence, experience with the activities, allowed their child greater risk taking even when not wearing safety gear.

Influence of child experience on permissible risk taking

To determine whether the parent’s ratings of their child’s experience with the activity (score range: 1–6) varied as a function of sex or play activity a MANOVA with sex (2) as a between-subjects factor and activity (7) as a within-subjects factor was performed. Results revealed that boys and girls had comparable levels of experience with the seven activities (p>0.05). However, level of experience varied with play activity, F(6, 364) = 62.03, p<0.01, as can be seen in table 3. Follow up tests, with a Bonferroni correction applied, indicated that the magnitude of the difference varied across play activity. Specifically, parents judged gear to be more efficacious to prevent injury for swimming, bicycling, and in-line skating than for the remaining activities, with no differences within each of these two groupings of activities. Hence, parents had the greatest confidence in the efficacy of safety gear to prevent injury for the gear that has been most widely acknowledged and publicized, namely gear for bicycling, swimming, and in-line skating.

When beliefs in gear efficacy scores were correlated with the magnitude of risk compensation scores it was found that mothers who believe in the efficacy of the safety gear showed greater risk compensation, swimming (r(54) = 0.21, p<0.05), bicycling (r(54) = 0.23, p<0.05), in-line skating (r(54) = 0.29, p<0.05), jumping on a trampoline (r(54) = 0.32, p<0.05), and running outside (r(54) = 0.47, p<0.05). And,

that shown for wearing a helmet when cycling or sledding, both of which resulted in substantial increases in permissible risk taking.

Parent’s beliefs about safety gear efficacy

To assess whether parent’s beliefs about safety gear efficacy (score range: 1–6) varied as a function of sex or play activity a MANOVA with sex (2) as a between-subjects factor and activity (7) as a within-subjects factor was applied to the data. Although no effect for sex was found, results indicated that parents’ perceptions about the efficacy of safety gear to prevent injury varied with activity type, F(6, 364) = 14.73, p<0.05, as seen in table 4. Pairwise comparisons, with a Bonferroni correction applied, indicated that the magnitude of the difference varied across play activity. Specifically, parents judged gear to be more efficacious to prevent injury for swimming, bicycling, and in-line skating than for the remaining activities, with no differences within each of these two groupings of activities. Hence, parents had the greatest confidence in the efficacy of safety gear to prevent injury for the gear that has been most widely acknowledged and publicized, namely gear for bicycling, swimming, and in-line skating.

Table 2

<table>
<thead>
<tr>
<th>Activity</th>
<th>Swim</th>
<th>Sled</th>
<th>Cycle</th>
<th>Skate</th>
<th>Climb</th>
<th>Jump</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>0.85 (2.6)</td>
<td>10.19 (19.0)</td>
<td>10.03 (7.2)</td>
<td>6.03 (5.2)</td>
<td>3.60 (3.5)</td>
<td>1.95 (1.5)</td>
<td>2.48 (2.6)</td>
</tr>
<tr>
<td>Girls</td>
<td>1.69 (2.2)</td>
<td>12.59 (13.1)</td>
<td>9.07 (8.1)</td>
<td>5.53 (4.1)</td>
<td>3.73 (8.7)</td>
<td>1.62 (1.0)</td>
<td>3.70 (2.8)</td>
</tr>
<tr>
<td>Overall</td>
<td>1.27 (2.4)</td>
<td>11.39 (16.2)</td>
<td>9.56 (7.6)</td>
<td>5.78 (4.6)</td>
<td>3.67 (6.6)</td>
<td>1.78 (1.3)</td>
<td>3.09 (2.7)</td>
</tr>
</tbody>
</table>

Note: scores exceeding 0 indicate risk compensation.

Table 3

<table>
<thead>
<tr>
<th>Activity</th>
<th>Swim</th>
<th>Sled</th>
<th>Cycle</th>
<th>Skate</th>
<th>Climb</th>
<th>Jump</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>3.70 (1.6)</td>
<td>4.37 (1.3)</td>
<td>4.37 (1.3)</td>
<td>3.00 (1.9)</td>
<td>4.56 (1.2)</td>
<td>0.59 (1.8)</td>
<td>3.11 (0.50)</td>
</tr>
<tr>
<td>Girls</td>
<td>4.19 (1.4)</td>
<td>4.11 (1.4)</td>
<td>4.11 (1.4)</td>
<td>2.59 (1.4)</td>
<td>4.48 (1.1)</td>
<td>0.52 (0.51)</td>
<td>3.37 (1.2)</td>
</tr>
<tr>
<td>Overall</td>
<td>3.94 (1.5)</td>
<td>4.24 (1.3)</td>
<td>4.24 (1.3)</td>
<td>2.80 (1.7)</td>
<td>4.52 (1.1)</td>
<td>0.56 (0.50)</td>
<td>3.24 (1.2)</td>
</tr>
</tbody>
</table>

Table 4

<table>
<thead>
<tr>
<th>Activity</th>
<th>Swim</th>
<th>Sled</th>
<th>Cycle</th>
<th>Skate</th>
<th>Climb</th>
<th>Jump</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>4.78 (1.0)</td>
<td>3.37 (1.1)</td>
<td>4.33 (1.3)</td>
<td>4.15 (1.2)</td>
<td>3.30 (1.1)</td>
<td>2.70 (1.1)</td>
<td>3.52 (1.2)</td>
</tr>
<tr>
<td>Girls</td>
<td>4.33 (1.2)</td>
<td>3.19 (1.2)</td>
<td>3.67 (1.4)</td>
<td>3.78 (1.1)</td>
<td>3.44 (1.3)</td>
<td>2.78 (1.2)</td>
<td>3.44 (1.1)</td>
</tr>
<tr>
<td>Overall</td>
<td>4.56 (1.1)</td>
<td>3.28 (1.1)</td>
<td>4.00 (1.4)</td>
<td>3.96 (9.1)</td>
<td>3.37 (1.2)</td>
<td>2.74 (1.2)</td>
<td>3.48 (1.0)</td>
</tr>
</tbody>
</table>
mothers who believed in the efficacy of safety gear indicated a greater tolerance for risk taking by their children when the safety gear was used, swimming (r = 0.43, p < 0.05), cycling (r = 0.31, p < 0.05), in-line skating (r = 0.26, p < 0.05), and jumping on a trampoline (r = 0.55, p < 0.05). Hence, in general, a belief in the efficacy of safety gear to moderate injury risk resulted in greater tolerance for children's risk taking by their mothers, resulting in greater risk compensation.

Finally, to explore mothers' spontaneous explanations for why they would allow greater risk taking under gear than no gear conditions their comments were examined. Coding of these fell into two categories: comments emphasizing an interpretation of the gear in terms of absolute risk (that is, the ability of the gear to completely prevent injury) and those emphasizing an interpretation of the gear in terms of relative risk (that is, the capacity of the gear to reduce injury risk and/or severity but not necessarily to eliminate injury risk completely). Scores were converted to proportions (that is, number of explanations that fell into each category of all those given by a mother) and separate analyses of variance were conducted for each activity, with explanation (two types) as a within-subjects factor. Results revealed significantly more absolute risk explanations than relative risk explanations for a number of activities. Specifically, absolute risk explanations predominated for swimming (M = 0.82, F (1, 44) = 13.54, p < 0.05), sledding (M = 0.76, F (1, 64) = 6.36, p < 0.05), cycling (M = 0.91, F (1, 104) = 30.89, p < 0.05), and in-line skating (M = 0.81, F (1, 102) = 22.26, p < 0.05). Hence, for those play activities for which safety gear are well known and publicized, mothers adopt an absolute risk framework and assume the gear will fully protect their child from injury, which probably explains their willingness to allow their child to engage in greater risk taking when wearing safety gear.

DISCUSSION
The present study examined whether safety gear influences what mothers think about their child's risk of injury and results in their intending to allow their child greater risk taking. Comparing the mother's ratings of permissible risk taking by their child when wearing safety gear to ratings when not wearing safety gear provided support for the notion of risk compensation: for all seven activities mothers intended to allow their child to engage in riskier behavior when wearing safety gear provided support for the notion of risk compensation. Hence, in general, a belief in the efficacy of the gear to prevent injury. Parents who rated gear as highly likely to prevent injury allowed children greater risk taking when using the gear. Moreover, the majority of parents judged the gear as an injury prevention measure, as opposed to a safety promotion or risk moderating measure. Hence, they failed to realize that injury risk is not absolute but relative, with the extent of risk determined by an interaction of environment and behavioral factors.

The problem of parents assuming absolute protection from safety gear, rather than relative protection, may contribute to explaining why there are such high rates of improper usage of infant safety seats and improper fitting bicycle helmets being worn by children. Possibly, use of these safety devices may lead parents to assume protection is assured, resulting in a failure of parents to attend to the detailed information that ensures proper usage. Obviously, there needs to be greater emphasis in communicating to parents the difference between absolute and relative risk and the potential limits of safety gear to prevent injury to children and/or to constrain the severity of injuries, particularly when the gear is not properly used.

Limitations and future research
The present results provide important information about factors influencing parents' perceptions of child injury risk. None of the less, there are some limitations to this study that need to be acknowledged, and there are a variety of outstanding issues that merit attention in future research. First, what parents report may not accurately reflect their behavior. Although it seems reasonable to assume that social desirability concerns by parents (for example, wanting to appear safety conscious and protective of their children) would have predicted a failure to find evidence of risk compensation in this study, it is still important to confirm that self reports showing risk compensation relate directly to parents' behavior. Second, it is also essential to establish whether children themselves show risk compensation as evidenced by increased risk taking under safety gear conditions and/or in reaction to skill development training with respect to recreational activities (for example, Canbike course) or injury management (for example, first aid course). Finally, although it may be difficult to study relations between risk compensation and child injury (rates, severity), such research is sorely needed. There is clear evidence that use of safety gear (for example, bicycle helmets) is associated with a reduction in serious injuries, such as head trauma (see Rivara et al and Scuffham et al). However, this does not necessarily imply that risk compensation is not operating at all. The difficulty in using injury statistics alone to establish whether risk compensation operates when safety gear is worn is that one has to estimate what might have been, that is, how much greater the reduction in injury might have been if children wore a helmet and they did not engage in increased risk taking. It may prove more productive for purposes of linking risk compensation to injury outcomes to adopt a multimeasure and longitudinal study strategy that includes observational measures of actual risk behavior, interviews to explore beliefs about personal injury vulnerability, and tracking of injury and near injury data. Obviously, more systematic research on risk compensation is needed before debates on this important issue (contrast Thompson et al and Adams and Hillman) can be resolved.

IMPLICATIONS FOR PREVENTION
Evidence of risk compensation among parents highlights the importance of communicating more than just a "Wear the Gear" message to parents. The present findings suggest that
focusing on safety gear utilization alone may be too narrow a strategy to maximize injury prevention and control among school age children. A message about the importance of safety gear needs to be balanced with one that emphasizes that gear is not a substitute for supervision and the importance of maintaining high standards limiting their children’s risk-taking behaviors.

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Key points
• Use of safety gear can lead parents erroneously to assume that the chance of injury is completely eliminated, resulting in parents showing greater tolerance for children’s injury risk behaviors when the gear is worn.
• “Wear the Gear” messages to parents may produce the greatest effects to moderate injury when supplemented by messages that call attention to the continuing need for supervision and reasonable limits on children’s risk-taking behaviors.