THE AVALUATOR AVALANCHE ACCIDENT PREVENTION CARD: FACTS, FICTIONS, AND CONTROVERSIES

Bob Uttl[1], Jan Uttl[2], & Meaghen Henry[1,3]
[1]Red Deer College, Red Deer, AB, Canada
[2]Avidata.ca, Cochrane, AB, Canada
[3]University of Calgary, Calgary, AB, Canada

ABSTRACT: The Avaluator Avalanche Accident Prevention Card, consisting of the Trip Planner and Obvious Clues (Haegeli and McCammon, 2006), is marketed as a decision support tool for helping users make decisions in avalanche terrain. For Obvious Clues, users count the number of obvious clues (e.g., loading, terrain trap), and the Avaluator tells them the percentage of historical accidents prevented, together with a travel recommendation: proceed with “normal caution”, “extra caution”, or “not recommended”. However, the prevention values in the Avaluator differ widely from values reported by the authors elsewhere as well as from various data sets reported by others (Uttl et al., 2007, 2008). To reconcile contradictory claims and data sets, we have (1) systematically reviewed all available literature on the development of the Avaluator and contacted the Avaluator's authors; and (2) modeled accident data using various assumptions about accident reports and human memory. Our review reveals a lack of methodological clarity and many contradictory and inconsistent claims about the development of the Avaluator and prevention values. Modeling demonstrates that the assumptions used to develop the Avaluator's prevention values result in severely biased prevention values that lead users to believe they would avoid a greater percentage of historical accidents than they actually would. These findings suggest that the Avaluator's accident prevention values gives users a false sense of security and that the use of the Avaluator may lead to more rather than fewer avalanche accidents.

KEYWORDS: Avalanche Education, Risk, Decision Making

1. INTRODUCTION

The Avaluator Avalanche Accident Prevention Card (Haegeli and McCammon, 2006) is marketed as a “Canadian made” and “science based” decision support tool for amateur recreationalists to help them prevent avalanche accidents, and thus, reduce their risk of becoming the next accident victims. The Avaluator consists of a Trip Planner and Obvious Clues. The Trip Planner helps users to select appropriate terrain for their next backcountry trip depending on the current Avalanche Danger Rating and the specific Avalanche Terrain Exposure Scale (ATES) rating. The Obvious Clues help users to assess whether specific slopes are safe to cross; users are advised to proceed with “normal caution”, “extra caution”, or “not recommended” depending on the number of obvious clues (out of seven) to avalanche hazard (i.e., avalanches, loading, path, terrain trap, rating, unstable snow, thaw instability).

Thus, before crossing the slope, users count the number of obvious clues using the Avaluator checklist and the Avaluator tells them the percentage of historical accidents prevented if historical users had limited themselves to crossing slopes with that number of Obvious Clues or fewer. For example, the Avaluator states that if historical users had limited themselves to crossing slopes with 4 or fewer obvious clues, 77% of historical accidents would have been prevented (i.e., prevention value or relative risk reduction is 77%).

In developing the Avaluator, Haegeli and McCammon (2006) reviewed over 1400 accidents, and for each record they determined whether each Obvious Clue (avalanches, loading, path, terrain trap, rating, unstable snow, thaw instability) was present, absent, or indeterminate from the record. Next, they deleted > 82% (!) of accidents that had indeterminate/missing values for one or more Obvious Clues and retained only 252 accidents in their sample. Table 1 shows the derivation of the prevention values based on this sample of 252 selected accidents. Haegeli and McCammon (2006) summed up the number of Obvious Clues (#OCs column) to obtain the frequency (n column), percentage (% column), and cumulative percentage (Cu% column) of avalanche accidents that occurred when 0 to 7 Obvious Clues were present. The last column shows the prevention or relative risk reduction values calculated by subtracting Cu% from 100. For a given number of clues, the prevention values tell users the percentage of accidents prevented if

Corresponding author address: Bob Uttl, Red Deer College, 100 College Blvd, Red Deer, AB, T4N 5H5, Canada; email: uttlbob@gmail.com

travel is restricted to slopes with the given or fewer number of obvious clues.

Surprisingly, a quick review of Haegeli and McCammon's own writings, reporting either frequency distribution of Obvious Clues or actual prevention values, reveals huge life vs. death inconsistencies between the prevention values reported in the Avaluator and in the authors' other writings. To illustrate, Figure 1 shows the frequency distribution of Obvious Clues reported by McCammon (2002) and McCammon (2004) vs. Heageli and McCammon (2006) in the Avaluator. The distributions are vastly different. For four or fewer Obvious Clues, McCammon's (2002, 2004) distributions yield prevention values of only 19.2 and 22.6% whereas the Avaluator distribution yields prevention value of 77%!

Table 1. Derivation of Prevention or Relative Risk Reduction Values (the Avaluator's 252 accidents).

#OCs	n	%	Cu%	PV/RRR
0	0	0	0	100
1	1	0	0	100
2	4	2	2	98
3	14	6	8	92
4	39	15	23	77
5	76	30	53	47
6	93	37	90	10
7	25	10	100	0

Note. OCs = number of Obvious Clues, n = number of accidents, % = percent of accidents, Cu % = cumulative percent of accidents, PV = Prevention Value, RRR = Relative Risk Reduction; N = 252.

What is the reason for the huge differences in the obvious clues distribution? Haegeli explained to us that the reason for the discrepancy is that “Ian [McCammon] initially developed the Obvious Clue measure to examine how much avalanche hazard avalanche victims KNOWINGLY [emphasis of Haegeli's] exposed themselves to at the time of the accident” (P. Haegeli, personal communication, March 29, 2008). However, this explanation contradicts McCammon's (2002) own description of his methods: “to minimize reporting biases, I chose indicators that would have been readily apparent not only to the victims, but also to any witnesses, rescue parties or investigators.” (p. 2). However, Haegeli subsequently refused to retract his allegation that McCammon (2002, 2004) misrepresented his method (P. Haegeli, personal communication, April 10, 2008) and when we contacted McCammon, McCammon refused to confirm or deny Haegeli's allegation (I. McCammon, personal communication, May 23, 2008).

This is intriguing. How does the same author (McCammon) arrive at such diametrically different conclusions? And why would Haegeli allege that McCammon (2002, 2004) misrepresented his method and why would McCammon decline to deny or to confirm Haegeli's allegations? The question whether the prevention values reported in the Avaluator are scientifically valid and accurate is of critical importance: if the prevention values reported in the Avaluator are invalid or inaccurate and true prevention values are closer to those derived from McCammon's (2002, 2004) data, the Avaluator will confer a false sense of security on its users and as a result some of them will be injured and others will die.

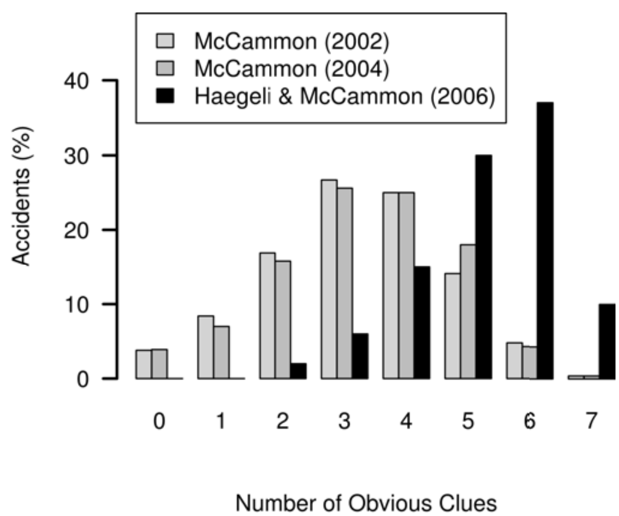

Figure 1. Accident percentage as a function of a number of obvious clues (normalized frequency distribution) reported by McCammon (2002, 2004) vs. Haegeli and McCammon (2006) in the Avaluator.

Are the prevention values in the Avaluator valid or invalid? To answer this question and to determine the reason for the discrepancies between McCammon (2002, 2004) data and the data reported in the Avaluator (Haegeli and McCammon, 2006), we reviewed McCammon's and Haegeli's writings related to the Obvious Clues method and the Avaluator and modeled accident data using different assumptions about accident reports and human memory.

2. REVIEW OF THE OBVIOUS CLUES METHOD

2.1 <u>*Obvious Clues: Review*</u>

Table 2 reviews the Obvious Clues (OC) methodology and OC means, medians, and prevention values for the three different OC limits (OC ≤ 2, OC ≤ 3, OC ≤ 4) reported by McCammon, Haegeli and their colleagues. Whereas the first three columns review the Obvious Clues method and findings as reported in McCammon (2000, 2002, 2004), the last five columns review the Obvious Clues method and findings based on the same sample of 252 accidents as reported in McCammon and Haegeli (2004, 2005, 2007), Haegeli et al. (2006), and Haegeli and McCammon (2006).

The review in Table 2 highlights severe deficiencies in the Obvious Clues methodology as well as numerous substantive inconsistencies and errors across various reports:

(1) Time period is missing in some reports.

(2) The *same 252 accidents* are described several times as US only accidents, one time as North American accidents, and one time as US and Canadian accidents. McCammon (I. McCammon, personal communication,May 23, 2008) claims that the 252 accidents were all US accidents. If so, the description of accidents as North American in the Avaluator is misleading and their description as US and Canadian in Haegeli et al., (2006) is wrong.

(3) The Obvious Clues count basis is reported in only two reports: McCammon wrote that he counted obvious clues apparent to victims, rescuers, and investigators (McCammon, 2002) and also to witnesses (McCammon, 2004). However, Haegeli alleged that McCammon actually counted only clues victims knowingly exposed themselves to (see above).

(4) Obvious Clues accident coding reliability is not reported anywhere – a significant methodological omission that undermines the validity of the findings in all of the reports.

(5) Missing data mechanisms – reasons why a coder could not determine whether each clue was present or absent – was not even considered in any of the reports.

(6) In one report, accidents with no Obvious Clues were excluded from analyses without any reason (McCammon, 2002). In another report, they were included in the analyses (McCammon, 2004). And in most of the reports, their exclusion or inclusion is not reported.

(7) Reporting on the same 252 accidents, McCammon and Haegeli contradict themselves when they claim that “accident data were used as reported, with no attempt made to fill in missing information with likely data” (McCammon and Haegeli, 2004, p. 4) and in later reports claim that “in some cases snowpack and weather data were derived from nearby observations” (McCammon and Haegeli, 2007, p. 198). Moreover, they provide no detail on how or from what the snowpack and weather data were “derived”.

(8) Reporting on the same 252 accidents, McCammon and Haegeli wrote that “In determining the prevention proportion (X) for each decision aid, we considered only accidents where there was sufficient information to compute an exact score for that decision aid.” (McCammon and Haegeli, 2007, p. 198; see also McCammon and Haegeli, 2004). Thus, McCammon and Haegeli used listwise deletion to eliminate accidents with missing values. In contrast, McCammon (2000, 2002, 2004) mentions no deletion of accidents due to missing values. Thus, the deletion of missing values is one possible reason for the discrepancy in the Obvious Clues distributions between the Avaluator and McCammon (2002, 2004) (see Figure 1).

(9) While users of the Avaluator are informed on the first page that the Avaluator is based on “more than 1,400 North American accidents” (Haegeli and McCammon, 2006, p. 1), *the same 252 accidents* are described elsewhere as originating from a review of 751 accidents. If one chooses to believe the value reported in the Avaluator, the authors dropped >82% of accidents due to missing values deletion and retained only <18% of them for calculation of the prevention values (see Table 1). Thus, users of the Avaluator falsely believe that the prevention values reported in the Avaluator are based on the analysis of > 1,400 accidents, when in fact they are based on only a small and most certainly biased subsample of only 252 accidents.

(10) Consistent with data in Figure 1, the mean number of Obvious Clues increased from 2.3 reported by McCammon (2000), to 3.3 reported by McCammon (2002, 2004), to 5.24 reported in the Avaluator (2006). Similarly, the prevention values of limiting one's travel to slopes with 4 or fewer clues increased from about 20% reported by McCammon (2002, 2004) to 77% reported in the Avaluator (Haegeli and McCammon, 2006).

(11) Haegeli et al. (2006) reported a different set of prevention values for *the same 252 accident sample*; they claimed that 2 or fewer clues prevent 90% of accidents whereas 4 or fewer clues

Table 2. Changes and Inconsistencies in Obvious Clues (OC) Methodology, OC Means, Medians, and Prevention or Risk Reduction Values for OC ≤ 2, OC ≤ 3, and OC ≤ 4.

				Reports on the same 252 accidents				
	M'00*	M'02	M'04	M&H'04	M&H'05	Haegeli et al.'06	H&M'06 Avaluator	M&H'07 CRS&T
Time period	1972 - 2000	1972 - 2001	1972 - 2003	1972 - 2004	1972 - 2004	?	?	1972 - 2004
Region	US only	US only	US only	US only	US only	Canada & US	North America	US only
Obvious Clues count basis	?	vic, res, inv[1]	vic, wit, res, inv[1]	?	?	?	?	?
Coding reliability	?	?	?	?	?	?	?	?
Missing mechanism	?	?	?	?	?	?	?	?
Zero OC exclusion	?	YES	NO	?	?	?	?	?
Data augmentation	?	?	?	NO	YES [weather]	?	?	YES [weather]
Listwise deletion	?	?	?	YES	?	?	?	YES
Initial sample	546	622	715	751	751	?	>1400	751
Final sample	344	598	715	252	252	? [252[2]]	[252[2]]	252
Deleted (%)	37.2	3.9	0	66.4	66.4	?	>82.0	66.4
Retained (%)	63.0	96.1	100	33.6	33.6	?	<18	33.6
OC (mean)	2.25	3.38	3.33				5.24	
OC (median)	2.23	3			5		5	
OC ≤ 2					98	90 [98[3]]	98	
OC ≤ 3		44.3	47.6	92	92		92	92
OC ≤ 4		19.3	22.6	77	77	47 [77[3]]	77	77

Notes: ? = not reported, not considered, or unknown
vic = victims, res = rescuers, wit =witnesses, inv = investigators
M'00 = McCammon (2000); M'02 = McCammon (2002); M'04 = McCammon (2004), M&H'04 = McCammon and Haegeli (2004); M&H'05 = McCammon and Haegeli (2005); Haegeli et al. '06 = Haegeli et al. (2006); H&M'06 = Haegeli and McCammon (2006); M&H'07 = McCammon and Hageli (2007)
[1] Haegeli claims that McCammon counted only clues victims knowingly exposed themselves to rather then clues apparent to victims, rescuers, investigators, and witness (see text).
[2] Haegeli confirmed that both Haegeli et al. (2006) and Haegeli and McCammon (2006) prevention values are based on only 252 accidents, the same accidents reported in *Cold Regions Science & Technology* (McCammon and Haegeli, 2007) (P. Haegeli, personal communication, March 29, 2008)
[3] Originally reported values corrected to new values (in brackets) on April 16, 2008 (Haegeli et al., 2006, corrected), in response to our inquiries into discrepancies between reported prevention values in various reports.
* McCammon (2000) counted Rating clue as present if Avalanche Danger Rating was “high or extreme” rather than “considerable or higher” in later writings.

prevent 47% of accidents. However, in response to our inquiries, Haegeli declared these values “typos” and corrected them to be consistent with the Avaluator to 98% and 77%, respectively (see April 16, 2008 revision).

2.2 *Obvious Clues: Science or Religion?*

The fundamental requirement of any scientific research is that research steps are repeatable and will lead to substantially the same results in the future. Thus, the method must describe in sufficient detail how the study was conducted to allow independent investigators to replicate the study if they want to.

However, Table 2 highlights that the research steps taken by McCammon and Haegeli are largely not repeatable because they are either not described or are described in contradictory ways. Unfortunately, Haegeli and McCammon repeatedly provided evasive or irrelevant answers, refused to clarify their methodology, refused to explain the discrepancies in their own writings (see Table 2 for examples), and refused to correct obviously incorrect statements (e.g., 252 accident sample cannot be both from “US only” and “US and Canada”).

Another fundamental requirement of scientific research is that the method and raw data are available for inspection and verification by other scientists and the public (Fisher, 2003). In light of Haegeli and McCammon's inconsistent statements about methods, sample, prevention values, etc., we asked for the list of 252 accidents selected out of more than 1,400. The authors repeatedly refused to provide this list. We later asked for access to the data for the limited purpose of verification of their substantive claims and prevention values but the authors again repeatedly refused to provide such access.

In summary, the review in Table 2, as well as the authors' repeated refusals to clarify the methods and to provide access to their raw data, highlight that McCammon and Haegeli's Obvious Clues method and prevention values are not replicable, and therefore, are not scientific. Like religion, the Obvious Clues method and associated prevention values are firmly placed in the domain of faith: you can chose to believe them or you can choose not to believe them.

2.3 *Obvious Clues: Summary*

Our review shows that the Obvious Clues method and prevention values are not replicable. However, one clear culprit for the discrepancy between the prevention values reported in the Avaluator (Haegeli and McCammon, 2006) and those reported by McCammon (2002, 2004) is the listwise deletion of accidents with missing values; that is, the deletion of all accidents where the authors could not establish the presence or absence of each obvious clue from accident records.

Indeed, Haegeli confirmed the listwise deletion of accident records prior to derivation of the prevention values for the Avaluator: “The criterion for deciding if an accident record had enough information to calculate a complete Obvious Clues Method score was quite simple. If there was enough information to explicitly determine the state of all 7 of the Obvious Clues, the case was included. If the status of fewer than all 7 clues could be determined, the case was excluded.” (P. Haegeli, personal communication, April 8, 2008). Thus, the Avaluator values are based on only 252 accidents out of >1400 after the authors deleted most of the accidents due to missing values. In contrast, McCammon (2004) deleted no accidents and McCammon (2002) deleted only a few accidents with zero Obvious Clues.

Clearly, contrary to Haegeli and McCammon's claims the Avaluator prevention values do not represent percentage of historical accidents avoided if travel is limited to specific number or fewer clues because they are based on less then 18% of available historical accidents and the authors made no attempt to establish that this selective sample is representative of all available accidents.

3. MODELLING ACCIDENT DATA USING DIFFERENT ASSUMPTIONS ABOUT ACCIDENT RECORDS AND HUMAN MEMORY

There are several special issues facing investigators wishing to make any conclusions from historical accident records: (1) Are available accident records representative?; (2) What is the mechanism and meaning of missing information in the accident records?; and (3) Is the accident coding method reliable, and therefore, replicable by others?

3.1 *Missing Data: 60 Second Tutorial*

What is the likely impact of deleting >82% of accident records on the calculated prevention values? Intuition, as well as research findings in cognitive science and memory, in particular a review of picture description, event description, and eyewitness testimony studies, indicates that witnesses typically notice and report things that are present, and only rarely mention the absence of things not present (Baddeley, 1990; Brewer and Treyens, 1981; Uttl and Graf, 2006).

Similarly, it is likely that avalanche accident reports omit information about various Obvious Clues, for example, obvious "significant melting of the snow surface", because victims, witnesses, rescuers, and accident investigators did not notice any significant melting of the snow surface, that is, significant melting of the snow surface was absent. Thus, the most reasonable assumption is that the missing values reflect the underlying absence of a specific Obvious Clue.

In technical terms, whenever the probability of a missing value depends on the underlying value of the variable (e.g., absence of Obvious Clue), the missing values are missing not at random (MNAR) and all statistics (e.g., means) will be biased estimates of population parameters (Little and Rubin, 1987; Schaffer and Graham, 2002).

In contrast, the assumption about missingness implicitly adopted by Haegeli and McCammon (2006) is that the missing data are missing completely at random (MCAR), that is, the complete cases (252 accidents) are *a random sample* from the original >1,400 accident records. This MCAR assumption is rarely tenable and clearly not tenable in this instance (Little and Rubin, 1987; Schaffer and Graham, 2002). As a result, the sample of 252 accidents selected by Haegeli and McCammon (2006) is severely biased towards accidents with many clues present because they are less likely to be deleted. In turn, the listwise deletion of cases with missing values is guaranteed to result in biased prevention values, for example, users are informed that with 4 or fewer Obvious Clues they will avoid 77% of accidents when in fact they will avoid a much smaller percentage of accidents.

3.2 *Missing Data Mechanism: Independent Estimates of Obvious Clues*

Whenever data are missing not at random (MNAR), it is critical that the researchers attempt to understand the mechanism leading to missing values and attempt to determine their meaning using, for example, external sources of data (Little and Rubin, 1987; Schaffer and Graham, 2002). For example, one may retrieve historical weather records to determine the likely presence or absence of the Thaw Instability Obvious Clue independent of the accident records.

Using an automated search, we retrieved summary weather data from the closest NOAA weather station for all accidents reported in *Avalanche Accidents in Canada Volume 4 1984-1996* (Jamieson and Geldsetzer, 1996) and calculated elevation appropriate maximum temperatures. Using the accident day maximum temperature > 0 Celsius as an indicator of possible Thaw Instability, we found evidence of possible Thaw Instability in 15% of accidents.

We examined Avalanche Bulletins for all Canadian avalanche accidents archived by Cyberspace Snow and Avalanche Center (www.csac.org) from October 1, 2000, to May 31, 2008, and extracted Danger Ratings, signs of Unstable Snow, and reports of Thaw Instability. The Rating of Considerable or higher was reported in 84% of Bulletins. The signs of Unstable Snow (whumpfing, cracking, hollow sound, collapsing) were reported in 9% of Bulletins. The signs of Thaw Instability (moist, wet, mushy snow) were reported in 19% of Bulletins.

These independent estimates fit extremely well with the prevalence of Unstable Snow and Thaw Instability clues in the avalanche accident records under the assumption that missing values reflect the absence of these clues (see for example, McCammon, 2002, 2004; see Figure 2). Thus, the assumption that missing data reflect the absence of Obvious Clues is supported by: (1) cognitive science and memory research; (2) objective external weather data records; and (3) subjective external avalanche bulletin data.

3.3 *Sensitivity Analysis: Different Assumptions = Different Prevention Values*

When the missing values are MNAR, it is necessary to make explicit assumptions about the missingness mechanism (Little and Rubin, 1987; Schaffer and Graham, 2002). The sensitivity analysis – calculating statistics under different explicit assumptions – reveals lower and upper bounds of possible prevention values.

For Obvious Clues, Figure 1 represents a rudimentary sensitivity analysis. McCammon (2002, 2004) unwittingly adopted the assumption that *missing values mean absence of Obvious Clues* (Missing Is Absence), that is, there is a strong (perfect or near perfect) correlation between missingness and the underlying value of obvious clue. Specifically, he unwittingly assumed that when an Obvious Clue is present victims, witnesses, rescuers and investigators are nearly certain to report its presence whereas if an Obvious Clue is absent, victims, witnesses, rescuers, and investigators are very unlikely to mention it. In contrast, for the Avaluator, Haegeli and McCammon (2006) implicitly adopted the assumption that *the missing values are missing completely at random* (Missing Is Random), that is, the 252 accident sample is a *random* sample (rather than selective sample) of >1,400 accidents they reviewed.

Thus, Figure 1 suggests that the prevention value of 4 or fewer clues is approximately 20% under the Missing Is Absence assumption but 77% under the Missing Is Random assumption.

We know from cognitive science and memory research that the Missing Is Absence assumption very likely corresponds to reality for all but the Rating clue (avalanche danger rating is not observed nor encountered but must be looked up prior to a trip) and that the Missing Is Random assumption is very likely untenable. Moreover, we also know that the independent estimates of at least Thaw Instability and Unstable Snow Obvious Clues strongly support the Missing is Absence assumption and contradict the Missing is Random assumption. In turn, independent evidence demonstrates that the Avaluator prevention values are untenable.

Moreover, the Avaluator prevention values mean that the historical avalanche accidents had on the average 5.24 Obvious Clues present. However, independent estimates of only three of the Obvious Clues (Thaw Instability: 0.15; Unstable Snow: 0.09; Rating, 0.84) reduce the maximum average number of the Obvious Clues to 5.08 (from a theoretical maximum of 7), well below the 5.24 average determined by the Avaluator. Thus, independent estimates of Obvious Clues indicate that the Avaluator's high prevention values are impossible.

3.4 *Coding Reliability*

Figure 2 shows the proportion of Obvious Clues reported in 344 accidents by McCammon (2000) and in 715 accidents by McCammon (2004). Since McCammon (2000) is a subset of McCammon (2004) data set, we calculated the proportion of accidents reporting each clue in the 371 newly added accidents (black bars). McCammon (2000, 2002, 2004) never reported any attempts to asses coding reliability. However, Figure 2 highlights that McCammon's (2004) coding *does not replicate* McCammon's (2000) coding. For example, prevalence of Traps increased from about 28% in McCammon (2000) to well over 80% in new accidents added in McCammon (2004), resulting in 58% prevalence of Traps across all accidents (old and new) in McCammon (2004). This discrepancy between the reported proportions are strong evidence of poor coding reliability and coding bias.

4. TWO SEASONS WITH THE AVALUATOR

Figure 3 shows the number of fatalities and number of accidents in Canada from 1984 until May 1, 2008. The 2002-03 season was termed “exceptional” because it resulted in 29 fatalities. However, this figure shows that this “exceptional” season was not that exceptional at all: there were 14 separate accidents and the number of fatalities was so high because two of the accidents (one involved a commercially guided tour and one involved a school tour with final decision making authority held by two teachers with avalanche training) resulted in 7 deaths each. The Avaluator was developed in response to this 2002-03 season to help amateur recreationalists. The Avaluator was introduced on the market on October 31, 2006 and 4,500 of Avaluators were sold within the first 2.5 months (www.avisualanche.ca, retrieved July 22, 2008). However, two years after its introduction, the last season on record, 2007-08, has so far resulted in 14 accidents, a number equal to the 2002-03 deadly season.

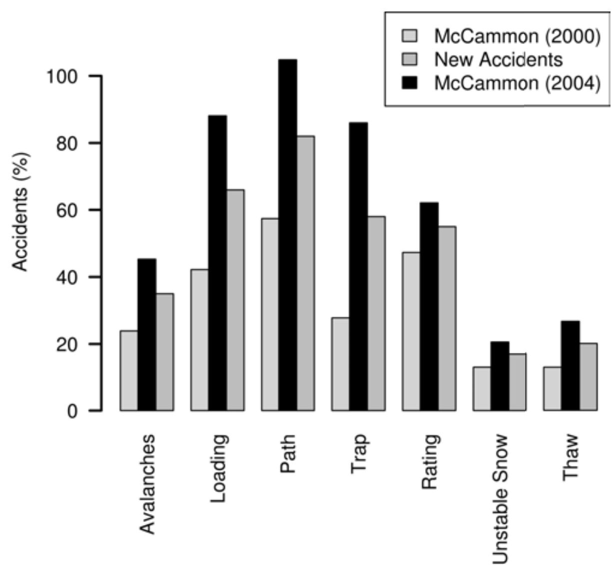

Figure 2. Percentage of accidents with each obvious clue in McCammon (2000) accident sample (n = 344), a new sample (n = 371) added to McCammon (2000) in McCammon (2004), and McCammon (2004) total sample (n = 715).

5. PUBLIC MONEY, SCIENCE, ETHICS, AND PUBLIC POLICY

The development of the Avaluator (Haegeli and McCammon, 2006) was sponsored by Parks Canada and funded by the New Initiative Fund grant from the National Search and Rescue Secretariat, Government of Canada, as part of the Canadian Avalanche Association's Decision Framework for Amateur Recreationist (ADFAR) project. The cost of the project exceeded $600,000 (Haegeli et al. 2006). The Avaluator is marketed as a “science based” decision tool, it has been incorporated into Canada's public awareness and prevention programs, and it is also now part of the curriculum of Avalanche Safety Training (AST) courses.

As noted above, Haegeli and McCammon repeatedly refused our requests to clarify their methods to allow independent replication of their study. They repeatedly refused to provide access to their data for the limited purpose of verifying their claims. The most basic aspects of their methodology remain unknown (e.g., accident sample, coding reliability, data augmentation). Indeed, their own data demonstrate that their methodology is either so unreliable as to produce inconsistent data or is changed from paper to paper. Either way, Haegeli and McCammon's failure to describe their methods in sufficient detail to allow replication of their studies render their studies, by definition, unscientific

McCammon and Haegeli published a report on the Obvious Clues prevention values in *Cold Region Science and Technology (CRS&T)*, a journal published by Elsevier. Elsevier's *Ethical Guidelines*, *Duties of Authors* section, states that authors “should be prepared to provide public access to such data.” Our request for the data pursuant to Elsevier's *Ethical Guidelines* was met with refusal and Dr. Timco, *Editor in Chief* of *CRS&T* explained that “I do not see how this statement [see above] calls for public access to data'” and continued “Nowhere does it state that they [authors] are required to do this” (G. Timco, personal communication, May 16, 2008). We have since confirmed that Elsevier's official interpretation of their own Ethical *Guidelines* is that the authors (1) *have a duty to be prepared to provide* access to data but (2) *have no duty to actually provide* access to data. Dr. Wallien, Publisher Geology, Elsevier, responding on behalf of Mark Seeley, Senior Vice President, Elsevier, clarified: “Our policies in this area focus on 'best practices' and encouraging transparency, rather than demanding or requiring it.” (F. Wallien, personal communication, June 2, 2008).

Thus, the development, as well as actual basis, of the tool used in public avalanche programs and endorsed by Parks Canada, the Canadian Avalanche Association, Provincial Emergency Program of British Columbia, and paid for by public funds from the Search and Rescue Secretariat, Canada, remains shrouded in secrecy. According to Dr. Timco and Dr. Wallien (G. Timco, personal communication, June 2, 2008; F. Wallien, personal communication, June 2, 2008), Haegeli and McCammon claim that they own intellectual property rights to the raw data they collected using Canadian taxpayers money, and they chose to hold their methods, accident sample information, as well as data in tight secrecy, away from scientific as well as public scrutiny.

Even if cognitive science research, as well as independent estimates of Obvious Clues, did not tell us that missing values represent absence of the Obvious Clues, a decision tool designed to prevent avalanche accidents and incorporated in public avalanche awareness and prevention programs *should err on the side of being conservative rather than liberal*, given the sensitivity analysis that reveals very different prevention values under different assumptions about the missing data mechanism. Thus, the Avaluator tells users that they will avoid 77% of accidents when it is more likely they will avoid a smaller percentage of accidents and perhaps only 20% or fewer accidents (McCammon, 2002, 2004). In turn, the Avaluator is inconsistent with Canada's Government public policy to protect Canadian lives and to help backcountry users make sound decisions to avoid avalanche accidents.

6. CONCLUSIONS

Discarding >82% of accident records, adopting the certainly untenable MCAR assumption about missingness, and giving no consideration to interrater reliability is nearly certain to produce a biased sample of accidents and biased accident prevention values. Not surprisingly, the evidence demonstrates that the Avaluator's prevention values are severely biased.

Intuition, evidence from cognitive science, and both objective (weather data) and subjective (avalanche bulletin reports by avalanche professionals) external evidence strongly support the assumption that missing values reflect the absence of Obvious Clues (with the exception of the Rating clue since it cannot be observed but must be looked up). In turn, the true prevention

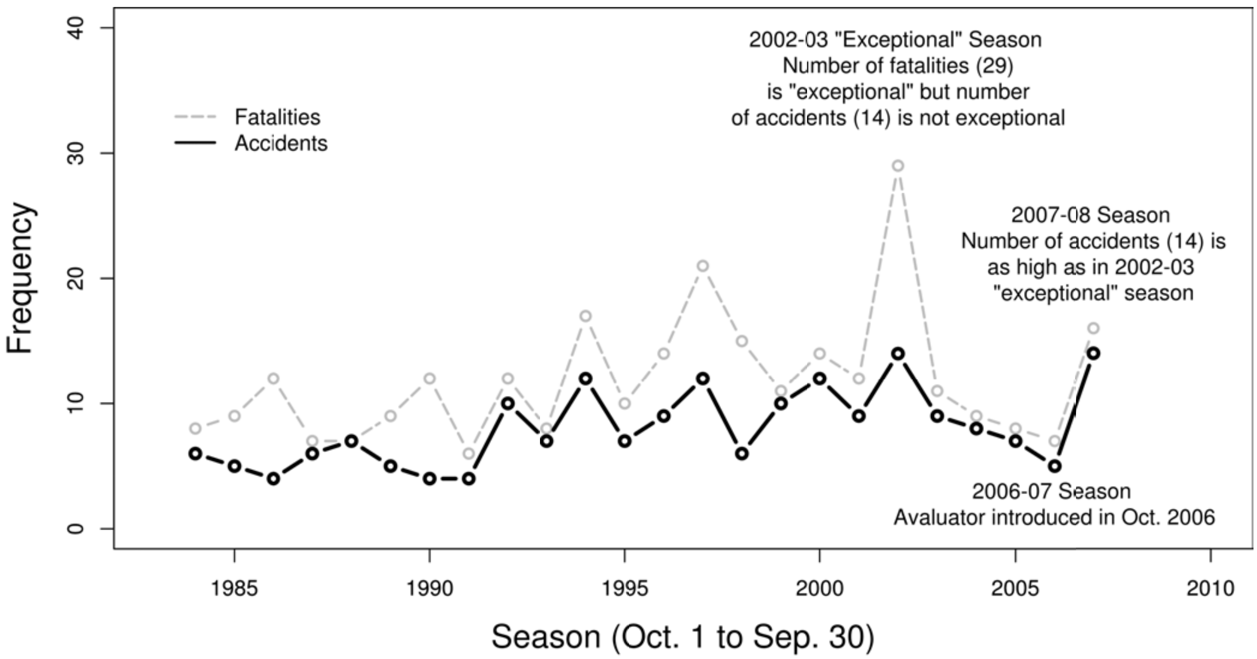

Figure 3. Frequency of accidents and fatalities by season. The 2002-03 "exceptional" season was exceptional in terms of number of fatalities (principally because two accidents resulted in 7 deaths each; one accident involved a commercially guided tour and another involved a school trip), but not at all exceptional in terms of accidents. Moreover, the 2007-08 season, the last season on record and the second season with the Avaluator, resulted in as many accidents as the "exceptional" 2002-03 season.

values of Obvious Clues are certainly closer to McCammon's (2002, 2004) values, rather than the Avaluator's values (Haegeli & McCammon, 2006). However, the coding reliability failure demonstrated in Figure 2 renders even McCammon's (2000, 2002, 2004) results questionable.

Thus, the evidence indicates that the Avaluator Avalanche Accident Prevention Card should perhaps be rebranded as the Avaluator Avalanche Accident Facilitation Card.

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