Weather Briefing Use and Fatal Weather Accidents

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This paper examines the quantitative reduction in risk associated with use of a weather briefing. It examines fatal weather accidents (accidents where weather is cited as a cause or a factor) that occurred during the 1964 to 1981 time period and documents statistics showing that pilots of these flights had a lower incidence of use of weather briefings than the pilot population overall. The study also notes that weather accidents represent almost 40 percent of all fatal accidents. They are characterized as being related most often to flight in low ceilings or when fog or rain is present. The types of pilot error in fatal weather accidents include continued visual flight into adverse weather conditions, improper preflight planning, and improper inflight decision making. The study uses Bayesian decision theory to estimate the probability of an accident with and without weather briefings from observable parameters such as the probability of an accident, the probability of use of weather briefings, and the probability that an accident flight had a weather briefing. The results show that a fatal weather accident is about 2½ to 3 times as likely if a flight did not have a weather briefing. The study also shows how increasing the incidence of use of weather briefings can reduce fatal weather accidents.

Although the safety value of obtaining weather briefing information prior to flying is well recognized by most aviators (*1, 2*), there has been almost no empirical research into the reduction in risk associated with the presence of such information for a flight. There is a history of interest in improving the dissemination of weather information in the United States (*3, 4*). But, even though a weather briefing is a regulatory requirement for cross-country flights in the United States (*5*), some pilots elect to fly without one.

The question of how aircraft accident rates would change if more or fewer flights had access to weather briefing information is difficult to examine directly because little information is available about the use of weather briefings for aircraft flights that did not result in an accident. Thus, it has been difficult to develop exposure-based measures of the increased risk of flying without weather information, in conditions where it could have made a difference in the outcome of the flight. Moreover, the absence or presence of weather briefing information is often unknown or not recorded during accident investigations by the National Transportation Safety Board (NTSB) or the Federal Aviation Administration (FAA).

This paper explores the value of a weather briefing in general aviation flying in the United States. It first develops data for weather-related accidents. It shows that fatal weather accidents occur under conditions that relate primarily to degraded ceilings and visibility, and nonfatal weather accidents occur under conditions that are dominated by unfavorable winds. The types of pilot causes cited in the accident record differ between fatal and nonfatal weather accidents.

The analysis employs Bayesian decision theory to infer the reduction in risk associated with the presence of weather briefing information. The probability of an accident given a weather briefing is compared to the probability of an accident given no weather briefing. These parameters are estimated using observed values for the probability of a weather briefing in the population of all flights and the probability of a weather briefing in accident flights. These data are applied to fatal accidents for which weather conditions were cited as a cause or factor in the NTSB accident records.

Changes in risk are estimated for single-engine and multiengine piston airplane accidents during the 1964 to 1981 time period. The change in risk varies by the estimated incidence of use of weather briefings in the overall population and the subset of fatal weather-related accidents. A "best" estimate is made along with upper and lower bounds on the estimates. The results show that, for single-engine piston airplanes, a fatal accident is over 2½ times as likely for flights that do not have access to weather briefing information.

WEATHER ACCIDENT DATA

Data showing the incidence of use of weather briefing information by type of flight and type of aircraft for U.S. general aviation are given in Table 1 (*5*, p. A-14). Among the principal aircraft types, multiengine piston and turbine engine aircraft have the highest incidence of use of preflight weather information. These data also show that about 50 percent of all local flights and 13 percent of all cross-country flights have no preflight weather briefing information. However, because a local flight is defined as one within 25 mi of the origin airport, a pilot is likely to encounter little change in the current weather. FAA regulatory standards (*6*) recognize this difference and impose more stringent weather information requirements on cross-country flights. The distribution of nonfatal and fatal weather accidents between local and cross-country flights is shown in Table 2. (Single-engine and multiengine piston airplanes account for the large majority of general aviation accidents. The remainder of this analysis is limited to these aircraft types.) The large majority of fatal weather accidents occurs on cross-country flights; local flights are significant only for nonfatal single-engine piston airplane accidents.

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TABLE 1 PERCENTAGE OF USE OF PREFLIGHT WEATHER INFORMATION SERVICES BY TYPE OF FLIGHT AND TYPE OF AIRCRAFT (5)

	Preflight Weather Information					
	FAA		Other		None	
Type of Aircraft	Local	Cross-Country	Local	Cross-Country	Local	Cross-Country
Single-engine piston (1 to 3 places)	31.8	70.7	17.8	19.0	53.4	15.9
Single-engine piston (4 places and over)	35.8	78.1	17.3	13.2	48.2	14.5
Multiengine piston	52.4	89.8	19.0	7.8	33.3	6.4
Rotorcraft piston	41.7	100.0	16.7	0.0	41.7	0.0
Rotorcraft turbine	53.8	76.0	11.5	28.0	46.2	12.0
Turboprop	75.0	89.5	25.0	10.5	0.0	6.1
Turbojet	0.0	97.1	0.0	2.9	100.0	0.0
Glider	12.0	N/A	28.0	N/A	60.0	N/A
All aircraft	34.3	79.5	17.6	13.2	50.0	12.6

NOTE: 1981 data.

TABLE 2 INCIDENCE OF LOCAL VERSUS CROSS-COUNTRY-FLIGHT WEATHER ACCIDENTS, 1964–1981

	Local		Cross-Country		
	No.	%	No.	%	Total
Multiengine piston airplanes					
Fatal	17	2.0	842	98.0	859
Nonfatal	39	4.8	774	95.2	813
Single-engine piston airplanes					
Fatal	277	7.8	3,266	92.2	3,543
Nonfatal	2,462	23.1	8,197	76.9	10,659

SOURCE: NTSB Accident Record

The principal benefits of weather briefings are likely to be evidenced in an examination of weather accident flights. As indicated in Table 3, weather accidents account for a significant proportion of all accidents (approximately 20 percent). In addition, a higher proportion of weather accidents involve fatalities than do nonweather accidents. Fatal accidents account for about 25 percent of all weather accidents in single-engine airplanes. In contrast, over 50 percent of the multiengine piston airplane weather accidents involve fatalities. This can be explained, in part, by the fact that these aircraft generally have a higher exposure to adverse weather, have a larger mass on collision, and may have higher impact speeds than do single-engine piston airplanes. (Annual accident rate data for single-engine and multiengine piston airplanes are contained in Appendix A, which is available from the author.)

The weather cause/factors for fatal weather accidents in single-engine piston airplanes are given in Table 4. Seven specific weather cause/factors account for almost 90 percent of

TABLE 3 COMPARISON OF FATALITY INCIDENCE, WEATHER VERSUS NONWEATHER ACCIDENTS, 1964–1981

	Weather Accidents		Nonweather Accidents	
	No.	%	No.	%
Single-engine piston				
Fatal	3,543	24.9	5,714	10.6
Nonfatal	10,659	75.1	47,988	89.4
Total	14,202	100.0	53,702[a]	100.0
Percent of all accidents	20.9		79.1	
Percent of fatal accidents	38.2		61.8	
Multiengine piston				
Fatal	859	51.4	986	15.1
Nonfatal	813	48.6	5,554	74.9
Total	1,672	100.0	6,540[b]	100.0
Percent of all accidents	20.4		79.6	
Percent of fatal accidents	46.6		53.4	

[a]Eight accidents classified as injury index unknown.
[b]One accident classified as injury index unknown.
SOURCE: NTSB Accident Record.

TABLE 4 FATAL AND NONFATAL WEATHER ACCIDENTS, INCIDENCE OF WEATHER CAUSE/FACTORS, FOR SINGLE-ENGINE PISTON AIRPLANES, 1964–1981

Cause/Factor	No.	Percentage
Fatal Weather Accidents		
Low ceilings	2,085	58.9
High-density altitude	234	6.6
Fog	230	6.5
Rain	154	4.4
Unfavorable winds	138	3.9
Thunderstorm activity	121	3.4
Turbulence	104	2.9
Subtotal	3,066	86.5
Total	3,543	100.0
Nonfatal Weather Accidents		
Unfavorable winds	5,336	50.1
Low ceilings	874	8.2
High-density altitude	845	7.9
Carburetor/induction icing	811	7.6
Updraft/downdraft	665	6.2
Sudden windshift	348	3.3
Fog	293	2.8
High temperature	297	2.8
Subtotal	9,469	88.8
Total	10,659	100.0

NOTE: The first weather cause/factor citation is used to define a weather accident. No multiple citations are used.

SOURCE: NTSB Accident Record.

TABLE 5 FATAL AND NONFATAL WEATHER ACCIDENTS, INCIDENCE OF PILOT ERROR CAUSE/FACTOR, FOR SINGLE- ENGINE PISTON AIRPLANES, 1964–1981

Cause/Factor	No.	Percentage
Fatal Weather Accidents		
Continued VFR flight into adverse weather conditions	1,583	44.7
Improper preflight preparation or planning	329	9.3
Attempted operation beyond experience/ability	231	6.5
Failed to obtain/maintain flying speed	206	5.8
Initiated flight in adverse weather conditions	203	5.7
Improper in-flight decision or planning	197	5.7
Spatial disorientation	123	3.5
Subtotal	2,872	81.1
Total	3,543	100.0
Nonfatal Weather Accidents		
Improper compensation for winds	1,115	10.5
Failed to maintain directional control	843	7.9
Failed to obtain/maintain flying speed	836	7.8
Inadequate preflight preparation or planning	816	7.7
Poor judgment	727	6.8
Improper operation of powerplant or powerplant controls	726	6.8
Continued VFR flight into adverse weather conditions	638	6.2
Improper level off	602	5.7
Improper operation of brakes or flight controls	427	4.0
Misjudged distance or speed	386	3.6
Improper in-flight decision	381	3.6
Unsuitable terrain	309	2.9
Subtotal	7,806	73.2
Total	10,659	100.0

NOTE: The first pilot cause cited in weather accidents is used to define pilot error rankings. No multiple citations are used.

SOURCE: NTSB Accident Record.

the fatal weather accidents. In fact, one cause/factor, low ceilings, accounts for almost 60 percent of those. Four of the seven fatal weather accident cause/factors (all except high-density altitudes, unfavorable winds, and turbulence) are related to degraded ceilings or visibility.

The weather cause/factors for nonfatal weather accidents are shown in Table 4. There are substantial differences between fatal and nonfatal weather accident cause/factors for the single-engine piston plane. There is a significant decrease in the importance of low ceilings and fog as cause/factors in nonfatal weather accidents and a substantial increase in accidents with unfavorable winds (or other wind-related categories) as a cause/factor.

The pilot cause/factors for fatal and nonfatal single-engine piston airplane weather accidents are shown in Table 5. The fatal accident pilot cause/factors are dominated by continuation of VFR (visual flight rules) flight into adverse conditions. Other fatal weather accident cause/factors are typified by improper planning or decisions. The nonfatal weather accidents are characterized by a wide range of pilot cause/factors that relate either to wind conditions in general or to difficulties in take-off and landing.

Weather cause/factors for multiengine piston airplane fatal and nonfatal weather accidents are shown in Table 6. Fatal accidents are characterized by low ceilings, icing, and cause/factors associated with precipitation. Eight weather cause/factors account for over 90 percent of all fatal multiengine piston airplane weather accidents. In comparison, nonfatal weather accidents are most often associated with unfavorable winds. However, in contrast to single-engine piston airplanes, this aircraft type shows a greater similarity of weather cause/factors between fatal and nonfatal accidents.

The data in Table 7 indicate that most fatal weather accidents for multiengine piston airplanes have pilot cause/factors associated with flying into adverse weather or improper operations in such conditions. Although nonfatal accidents evidence some problems with a pilot's inability to deal with severe weather or with improper response to adverse weather conditions, they are associated more often with flight techniques such as problems in level off, directional control, speed control, operation of power plant controls, and so on.

The data in Tables 4 through 7 show that fatal weather accidents occur more often in precipitation or degraded visibility conditions and have different pilot cause/factors than do nonfatal weather accidents. When weather cause and pilot cause are considered together, fatal weather accidents appear to represent a more homogeneous subset than do nonfatal weather accidents. (For more information, see Appendix B available from the author.) For these reasons, it appears that fatal weather

TABLE 6 FATAL AND NONFATAL WEATHER ACCIDENTS, INCIDENCE OF WEATHER CAUSE/FACTORS, FOR MULTIENGINE PISTON AIRPLANES, 1964–1981

Cause/Factor	No.	Percentage
Fatal Weather Accidents		
Low ceilings	512	59.6
Icing (airframe, prop, etc.)	68	7.9
Fog	53	6.2
Rain	37	4.3
High density altitude	31	3.6
Turbulence	28	3.3
Thunderstorm activity	25	2.9
Snow	23	2.7
Subtotal	777	90.5
Total	859	100.0
Nonfatal Weather Accidents		
Unfavorable winds	210	25.8
Low ceilings	163	20.1
Icing (airframe, prop, etc.)	94	11.6
High density altitude	58	7.1
Fog	57	7.0
Carburetor/induction icing	51	6.3
Rain	48	5.9
Updraft/downdraft	35	4.3
Snow	25	3.1
Subtotal	741	91.1
Total	813	100.0

NOTE: The first weather cause or factor is used to define a weather accident. No multiple citations are used.

SOURCE: NTSB Accident Record.

TABLE 7 FATAL AND NONFATAL WEATHER ACCIDENTS, INCIDENCE OF PILOT CAUSE/FACTORS, FOR MULTIENGINE PISTON AIRPLANES, 1964–1981

Cause/Factor	No.	Percentage
Fatal Weather Accidents		
Continued VFR flight into adverse weather	220	25.6
Improper IFR operation	129	15.0
Improper preflight preparation or planning	75	8.7
Improper in-flight decision or planning	70	8.2
Failed to obtain/maintain flying speed	44	5.1
Initiated flight into adverse weather	38	4.4
Spatial disorientation	36	4.2
Attempted operation beyond experience/ability level	29	3.4
Attempted operation with known deficiencies in equipment	26	3.0
Subtotal	667	77.6
Total	859	100.0
Nonfatal Weather Accidents		
Improper level off	67	8.2
Improper IFR operation	66	8.1
Inadequate preflight preparation or planning	59	7.3
Improper operation of powerplant or powerplant controls	48	5.9
Failed to maintain directional control	48	5.9
Improper in-flight decision or planning	45	5.5
Continued VFR flight in adverse weather	40	4.9
Failed to obtain/maintain flying speed	36	4.4
Misjudged distance or speed	33	4.1
Improper compensation for winds	32	3.9
Improper operation of brakes or flight controls	27	3.3
Poor judgment	25	3.1
Subtotal	526	65.0
Total	813	100.0

NOTE: The first pilot cause factor cited in weather accidents is used to define the pilot error rankings. No multiple citations are used.

SOURCE: NTSB Accident Record.

accidents are likely to be more influenced by the absence or presence of a weather briefing than are nonfatal weather accidents. Thus, further analyses in this paper are based on fatal weather accidents only.

USE OF WEATHER BRIEFING INFORMATION

The data in Table 8 show the incidence of use of weather briefing services by flights involved in weather accident flights. The data show that multiengine airplanes evidence a higher use of weather briefing services than do single-engine piston airplanes. Weather briefings as counted in the accident record include both full and partial briefings which were delivered by telephone, by radio, or in person.

Comparable data for the use of weather briefing services by all flights are shown in Table 9. There are few comprehensive data about the relative use of weather briefing services by general aviation pilots under differing conditions. It must be recognized that the weather briefing frequency of use by general aviation aircraft depends on a number of factors in addition to the local and cross-country flying distinctions noted in Table 1. For example, the actual weather at the time of flight may influence a pilot's decision to obtain a weather briefing. The data in Table 9 were calculated on three bases to provide a lower bound estimate, a best estimate, and an upper bound estimate for the population use of weather briefing services.

The following factors serve to make the above estimates conservative:

- Weather briefing incidence in the records of fatal weather accident flights considers both preflight and in-flight weather information. In all three cases, the population proportions are based only on the use of preflight weather briefings.
- In the lower bound and best estimate cases, the population use of weather briefings was estimated from 1981 survey data which were collected after the onset of the PATCO air traffic controllers strike. Flight service station briefers at FAA did not strike; however, there was a significant reduction in IFR (instrument flight rules) flights due to air traffic control system constraints. A similar survey for 1978 showed a much higher incidence of use of weather briefing services and this was used for the upper bound case.
- Fatal weather accident flights occur largely in marginal or bad weather. The population proportion of use of weather briefings is based on flying in all weather conditions, which makes this estimate conservative.

TABLE 8 FREQUENCY OF WEATHER BRIEFINGS FOR WEATHER ACCIDENT FLIGHTS

	Multiengine Piston		Single-Engine Piston	
Type of Weather Briefing	Fatal	Nonfatal	Fatal	Nonfatal
No entry	37	154	238	2,937
National Weather Service	51	39	167	248
Flight service station	565	416	1,761	2,706
None	142	100	1,086	3,441
Other	37	58	143	550
Unknown	27	46	148	777
Total accidents	859	813	3,543	10,659
Accidents with known status	795	613	3,157	6,945
Percent briefed	82.1	83.7	65.6	49.5

SOURCE: NTSB Accident Record.

TABLE 9 ESTIMATED INCIDENCE OF USE OF PREFLIGHT WEATHER BRIEFINGS, POPULATION USE AND FATAL WEATHER ACCIDENT USE (*7, 8*)

	Lower Bound Estimate[a]	Best Estimate[b]	Upper Bound Estimate[c]
Single-engine piston	72.3	82.9	92.8
Multiengine piston	88.8	93.1	96.6

[a]The lower bound case was calculated from the *1981 General Aviation Pilot and Aircraft Activity Survey* (*7*) by weighting the percentage of local and cross-country flights that used no preflight weather briefing services by the incidence of such flying. The percentage of flights that used no services was subtracted from one to produce the percentage of flights that did use services.

[b]The best estimate of the population use of weather briefing services was made by applying the percentage of fatal weather accidents that were local and cross-country to the incidence of such flights in the *1981 General Aviation Pilot and Aircraft Activity Survey* (*7*). The result was subtracted from one to produce the percentage of flights that did use those services.

[c]The upper bound case was calculated from the *1978 General Aviation Pilot and Aircraft Activity Survey* (*8*). It shows the same percentage use of preflight weather briefings for local and cross-country flights.

SAFETY VALUE OF WEATHER BRIEFING

The methodology to evaluate the value of weather briefing (Methodology I) was developed using a Bayesian decision theory approach. The Bayesian approach uses information about prior probabilities and applies empirical evidence to yield posterior probabilities. It enables examining the relative difference in the probability of a fatal weather accident given that a pilot did or did not have a weather briefing. The principal assumption in the analysis is that the weather briefing information is a critical differentiator in safety performance for fatal weather accidents. The methodology to evaluate the value of weather briefing (Methodology I) follows:

Methodology I

given

- $P(A)$ = probability of an accident
- $P(B)$ = probability of a weather briefing
- $P(A/B)$ = probability of an accident given a weather briefing
- $P(A/\bar{B})$ = probability of an accident given no weather briefing
- $P(B/A)$ = probability of a weather briefing given an accident
- $P(\bar{B}/A)$ = probability of no weather briefing given an accident

and

$$P(A/B) = \frac{P(B/A)\,P(A)}{P(B)}$$

$$P(A/\bar{B}) = \frac{P(\bar{B}/A)\,P(A)}{P(\bar{B})}$$

then

$$\frac{P(A/\bar{B})}{P(A/B)} = \frac{P(\bar{B}/A)\,P(B)}{P(\bar{B})\,P(B/A)}$$

$$= \frac{[1 - P(B/A)]\,P(B)}{[1 - P(B)]\,P(B/A)}$$

The results of the Bayesian analysis are shown in Table 10. For single-engine piston airplanes, the "best estimate" of the probability of a fatal weather accident is over 2.5 times as great if a flight did not have a weather briefing as if it did (lower bound: 1.4 times as great; upper bound: 6.8 times as great). For multiengine piston airplanes, the "best estimate" is that a flight without a weather briefing is almost three times as likely to have a fatal weather accident if it did not have a preflight weather briefing (lower bound: 1.7 times as likely; upper bound: 6.2 times as likely).

TABLE 10 ESTIMATED VALUE OF WEATHER BRIEFING, FATAL WEATHER ACCIDENTS

	Lower Bound Estimate	Best Estimate	Upper Bound Estimate
Single-engine piston	$P(B) = 72.3\%$ $P(B/A) = 65.6\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 1.37$	$P(B) = 82.9\%$ $P(B/A) = 65.6\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 2.54$	$P(B) = 92.8\%$ $P(B/A) = 65.6\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 6.76$
Multiengine piston	$P(B) = 88.8\%$ $P(B/A) = 82.1\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 1.73$	$P(B) = 93.1\%$ $P(B/A) = 82.1\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 2.94$	$P(B) = 96.6\%$ $P(B/A) = 82.1\%$ $\frac{P(A/\bar{B})}{P(A/B)} = 6.19$

NOTE: $\underline{P(A/\bar{B})}$ = probability of weather accident with no weather brief; $P(B)$ = probability of a weather accident with a weather brief.

SOURCE: Data from Table 8 and 9 evaluated using Methodology I.

METHODOLOGY TO EVALUATE CHANGES IN USE OF WEATHER BRIEFINGS

The methodology used to estimate the number of accidents with varying levels of use of weather briefing services (Methodology II) follows:

Methodology II

given

$N(A/\bar{B})$	=	number of accidents—no flights briefed
$N(A/B)$	=	number of accidents—all flights briefed
OA	=	observed annual average accidents
$P(B)$	=	proportion of flights briefed
$N(A)$	=	estimated number of accidents
$FLIGHTS$	=	annual aircraft flights

and

$$N(A/\bar{B}) = P(A/\bar{B})\ FLIGHTS$$

$$N(A/B) = P(A/B)\ FLIGHTS$$

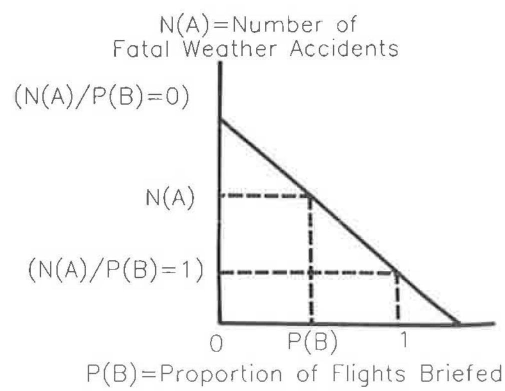
then

$$N(A) = P(A/B)P(B)\quad FLIGHTS + P(A/\bar{B})\ (1 - P(B)]\quad FLIGHTS$$

$$N(A) = N(A/B)\ P(B) + N(A/\bar{B})\ [1 - P(B)]$$

$$N(A) = N(A/\bar{B}) - [N(A/\bar{B}) - N(A/B)]\ P(B)$$

The accident flight use of weather briefing services (Table 8) and the population use (Table 9) (*7, 8*) are employed to estimate the probability of an accident if all flights are briefed and if no flights are briefed. This approach calculates the potential number of accidents in each case using the observed accidents. It should be noted that this approach is valid for a level of use of weather briefings that is not widely divergent from the actual use of weather briefings by the population. This is graphically portrayed in Figure 1. It also shows that even if all flights are briefed—$[N(A)/P(B) = 1]$—some weather accidents would still occur. This results from the fact that weather briefing information is only one factor in fatal weather accident flights.



N(A)=(N(A)/P(B)=0)−[N(A)/P(B)=0−N(A)/P(B)=1]P(B)

Source: Derived from Methodology II.

FIGURE 1 Graphical depiction of the change in fatal weather accidents from different levels of use of weather briefing information by U.S. general aviation pilots.

The data in Table 11 provide the basic values for use in calculating the number of fatal weather accidents estimated to occur under varying levels of use of weather briefing information. They are used in the next section to show how the number of fatal weather accidents could change if the proportion of flights using weather briefings was increased.

CHANGES IN ACCIDENTS RESULTING FROM CHANGES IN USE OF WEATHER BRIEFINGS

The data in Table 12 show the increase in safety associated with a hypothetical 3 percent increase in weather briefing use by the pilot population. Such a change could be achieved by a number of means:

- Increased availability and convenience of use;
- Increased FAA enforcement for nonuse of required weather briefings; and
- Incentives from insurance companies for pilots who agree to receive a weather briefing for all flights (i.e., reduced

TABLE 11 BASELINE VALUES FOR CALCULATIONS OF NUMBER OF FATAL WEATHER ACCIDENTS UNDER CHANGES IN USE OF WEATHER BRIEFINGS

	Lower Bound Estimate	Best Estimate	Upper Bound Estimate
Single-engine piston	$OA = 196.8$	$OA = 196.8$	$OA = 196.8$
	$P(A/\bar{B}) = 1.24\ P(A)$	$P(A/\bar{B}) = 2.01\ P(A)$	$P(A/\bar{B}) = 4.78\ P(A)$
	$P(A/B) = 0.91\ P(A)$	$P(A/B) = 0.79\ P(A)$	$P(A/B) = 0.71\ P(A)$
	$N(A/\bar{B}) = 244.4$	$N(A/\bar{B}) = 359.9$	$N(A/\bar{B}) = 940.3$
	$N(A/B) = 178.5$	$N(A/B) = 155.7$	$N(A/B) = 139.1$
Multiengine piston	$OA = 47.7$	$OA = 47.7$	$OA = 47.7$
	$P(A/\bar{B}) = 1.60\ P(A)$	$P(A/\bar{B}) = 2.59\ P(A)$	$P(A/\bar{B}) = 5.27\ P(A)$
	$P(A/B) = 0.93\ P(A)$	$P(A/B) = 0.88\ P(A)$	$P(A/B) = 0.85\ P(A)$
	$N(A/\bar{B}) = 76.2$	$N(A/\bar{B}) = 123.6$	$N(A/\bar{B}) = 251.1$
	$N(A/B) = 44.1$	$N(A/B) = 42.0$	$N(A/B) = 40.5$

SOURCE: Data from Tables 3 and 10 evaluated using Methodology II.

TABLE 12 ESTIMATED CHANGE IN FATAL WEATHER ACCIDENTS FROM INCREASE IN USE OF WEATHER BRIEFING SERVICES OF 3 PERCENT

	Lower Bound	Best Estimate	Upper Bound
Single-engine piston airplanes			
Probability of briefing: $P(B)$	.745	.854	.956
Estimated number of accidents: $N(A)^a$	195.3	190.8	174.4
Observed annual average accidents: OA	196.8	196.8	196.8
Change in accidents	−1.5	−6.0	−22.2
Multiengine piston airplanes			
Probability of briefing: $P(B)$	.915	959	.995
Estimated number of accidents: $N(A)^a$	46.8	45.3	41.6
Observed annual average accidents: OA	47.7	47.7	47.7
Change in accidents	−0.9	−2.4	−6.1

NOTE: Change in use of weather briefings = +3 percent.
[a]Using Methodology II.

premiums for weather-brief use, conditioned on reduced coverage if involved in accident without having received a weather briefing).

Any safety improvement would result from increased use of weather briefings by the overall pilot population; that is, accident flights cannot be selectively targeted. The Bayesian model allows an estimate of the reduction in accidents as a result of increased population use of weather briefings. For example, as shown in Table 12, a 3 percent increase in the population use of weather briefings is projected to reduce fatal weather accidents by about six accidents per year for single-engine piston airplanes (best estimate). Depending on the true population use of weather briefings, the reduction in accidents could range from 1.5 to 22.2 per year. If a high current level of weather briefing use is assumed, changes in the proportion of pilots briefed can have a significant effect on the number of accidents. However, the maximum reduction possible occurs when all flights are briefed (i.e., $P(B) = 100$ percent). This level of use would reduce fatal weather accidents in multiengine piston airplanes by 7.2 in the upper-bound case. (For single-engine piston airplanes, 100 percent use of weather briefings is estimated to reduce fatal weather accidents by 57.7 per year.)

Decreases in the use of weather briefings were evaluated in a study of the effects of user fees on such services (*9*). Another study (*10*) examined how estimated changes in the level of use of weather briefings at various fee levels could be used to determine the value that aviators implicitly place on avoiding loss of life.

CONCLUSIONS

The most significant issue in the application of the results of this study is the uncertainty regarding the level of use of weather briefing by the pilot population. Changed assumptions about the present level of use of weather briefings have significantly different implications for the accident-reduction potential than increasing the population use of weather briefings. Nonetheless, the analysis shows that increases in the use of weather briefings can result in reducing the number of fatal weather accidents.

Future research into the role of weather briefings in fatal weather accidents is warranted. One approach would be to explore how accident rates differ for flights that received briefings from different sources (e.g., FAA, National Weather Service, private company, etc.). Another research topic of interest would be to study how differences between predicted conditions in a weather briefing and actual weather encountered affect safety. However, both of these topics are likely to require that additional information be developed on the performance of nonaccident flights.

ACKNOWLEDGMENT

The application of the Bayesian methodology to the problem in this paper was conceived of by Earl Bomberger of Gellman Research Institute. This work would not have been possible without his important contributions.

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The research underlying this paper was funded by the FAA, U.S. Department of Transportation. However, it does not assume responsibility for the results presented herein.

Publication of this paper sponsored by Committee on Light Commercial and General Aviation.