Lecture 03

A Risk Analysis Model: Fly or Drive?

Modeling Risk

FLY or Drive (or who you should believe)

Use of models

Appropriate basis for risk calculation (exposure)

Interaction of factors

Parameter estimation

Learning objectives

1. be able to describe factors affecting airline/auto safety
2. know why we need to model risks
3. be able to construct & use simple models of fatality rates

Ford Motor

New study released: Several cars had higher driver death rates than the four-door, four-wheel-drive Explorer that is most popular.

Ford Motor

'Anomaly': The two-door, two-wheel-drive Explorer scored much worse than its four-door counterpart in terms of driver death rate.

Crash study ranks deadly vehicles

Explorer better than some cars

By James R. Healey
USA TODAY

Some family cars are more likely to kill their drivers than the benighted Ford Explorer sport-utility vehicle is.

Some cars even have deadly rollover wrecks at about the same rate as the most-popular version of Explorer, though the cars would earn good rollover rankings — three or four stars — and the Explorer would get just two in the first federal scores due soon.

The surprising information comes from an analysis by the Insurance Institute for Highway Safety (IIHS) of fatal crashes in 1995-98 that involved 1994-97 models. It's a rough gauge of vehicle instability — how easily vehicles roll over in real-world conditions — using federal fatality statistics and R.L. Polk vehicle registrations.

The analysis also gives a driver death rate, expressed as driver deaths per million registered-vehicle years.

A vehicle registered each of the four years of the study counted as four registered-vehicle years. A vehicle registered only one year was one vehicle year.

Overall average was 89 driver deaths per million registered-vehicle years in all types of accidents. What might be considered an instability score — the portion of single-vehicle fatalities involving rollovers — averaged 58.7%.

The most-popular version of Explorer (59.3% of Explorers in the IIHS analysis) had a driver death rate of 56 and an instability score of 70.3%.

Averages for similar SUVs: driver death rate, 72; instability score, 79.6%.

The IIHS work was completed this summer, before the recall. The organization won't label Explorer stable or unstable, based on the findings.

Other Explorer models:

Four-door, two-wheel drive (27.5% of the total) — 103 driver death rate, 86% instability score. Averages for similar two-wheel-drive SUVs: 126 and 88.5%.

Two-door, four-wheel-drive Explorer

Driver death rates in car crashes

Ford Explorer sport-utility vehicle is under fire for rollover accidents involving Firestone tires, but some cars are worse. They kill their drivers at a higher rate, and are about as likely to roll over and kill their drivers in single-vehicle crashes as the Explorer is, according to an analysis by the Insurance Institute for Highway Safety.

Model year	Vehicle	Driver death rate in single and multiple-vehicle crashes[1]	% of single-vehicle driver deaths in a rollover
1995-97	Subaru Legacy/Outback station wagon	74	100.0%
1994-97	Oldsmobile Achieva, 2-dr	163	77.1%
1995-97	Chevrolet Cavalier, 2-dr	133	74.7%
1995-97	Geo Metro, 4-dr	212	73.3%
1994-97	Pontiac Grand Am, 2-dr	132	70.5%
1996-97	Dodge Neon/Plymouth Neon, 2-dr	143	70.5%
1995-97	**Ford Explorer 4-dr, 4-wheel drive**	**56**	**70.3%**
1995-97	Hyundai Accent, 2-dr	177	69.8%
1995-97	Chevrolet Monte Carlo, 2-dr	117	65.4%
1994-97	Chevrolet Camaro convertible	290	65.2%
1994-97	Pontiac Grand Am, 4-dr	120	64.2%
1997	Ford Escort, 4-dr	95	63.6%
1994-97	Chrysler LHS, 4-dr	59	62.5%
1995-97	Nissan 200SX, 2-dr	119	61.4%
1995-97	Chevrolet Lumina, 4-dr	90	60.9%
1994-97	Ford Crown Victoria, 4-dr	77	60.0%

1 - Driver deaths per million registered-vehicle years, single- and multiple-vehicle crashes.

Source: Insurance Institute for Highway Safety

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Source: Insurance Institute for Highway Safety

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CRITERIA

Driver deaths in crashes
per million registered vehicle years

% of single-vehicle driver deaths in rollovers

Better criteria deaths per mile?

Death Rate

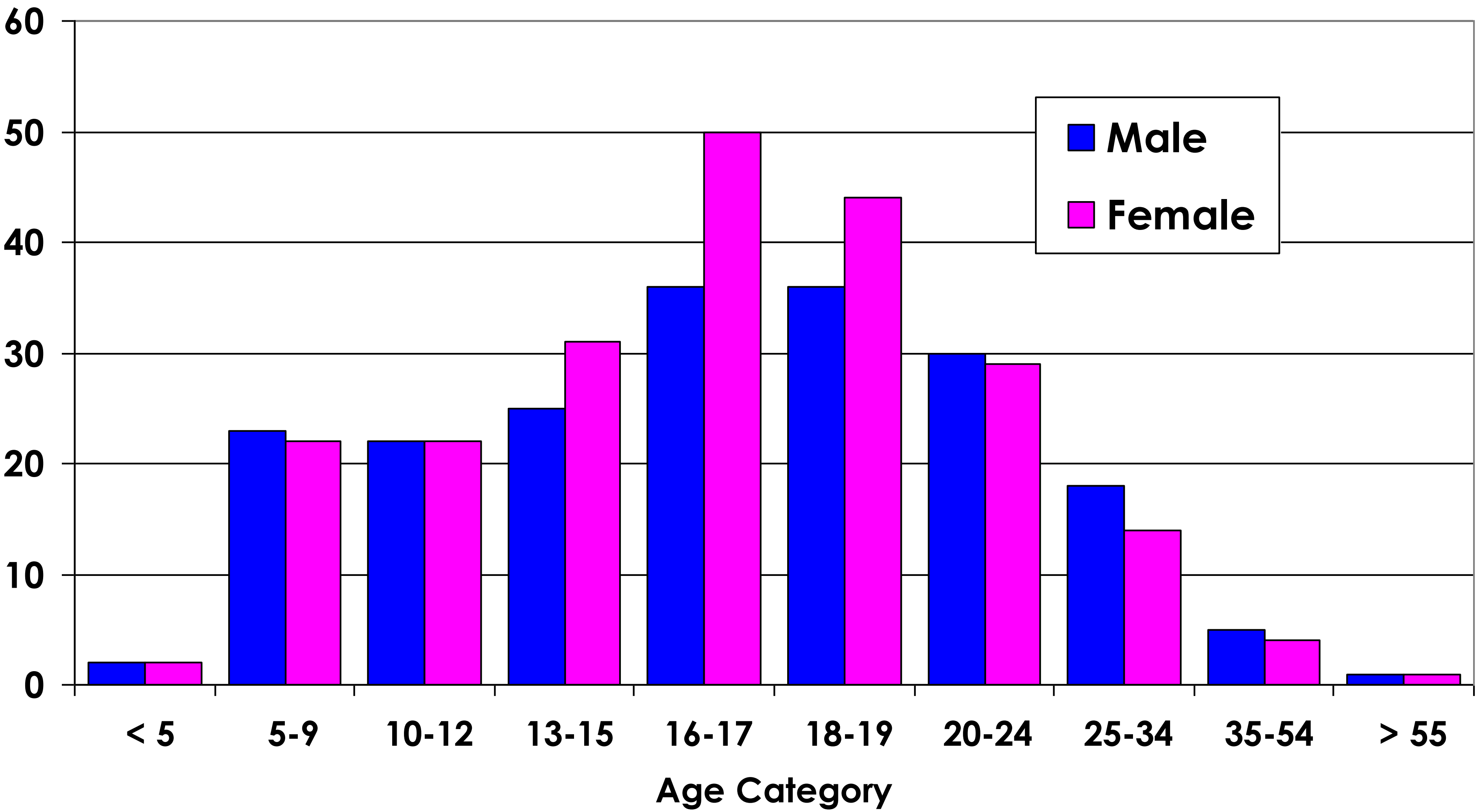
	death rate	% in rollovers
Popular Explorer 4-door, 4-drive	56	70.3
Explorer 4-door, 2-drive	103	86.5
Average SUVs	72	79.6
Explorer 2-door, 2-drive	231	86.7

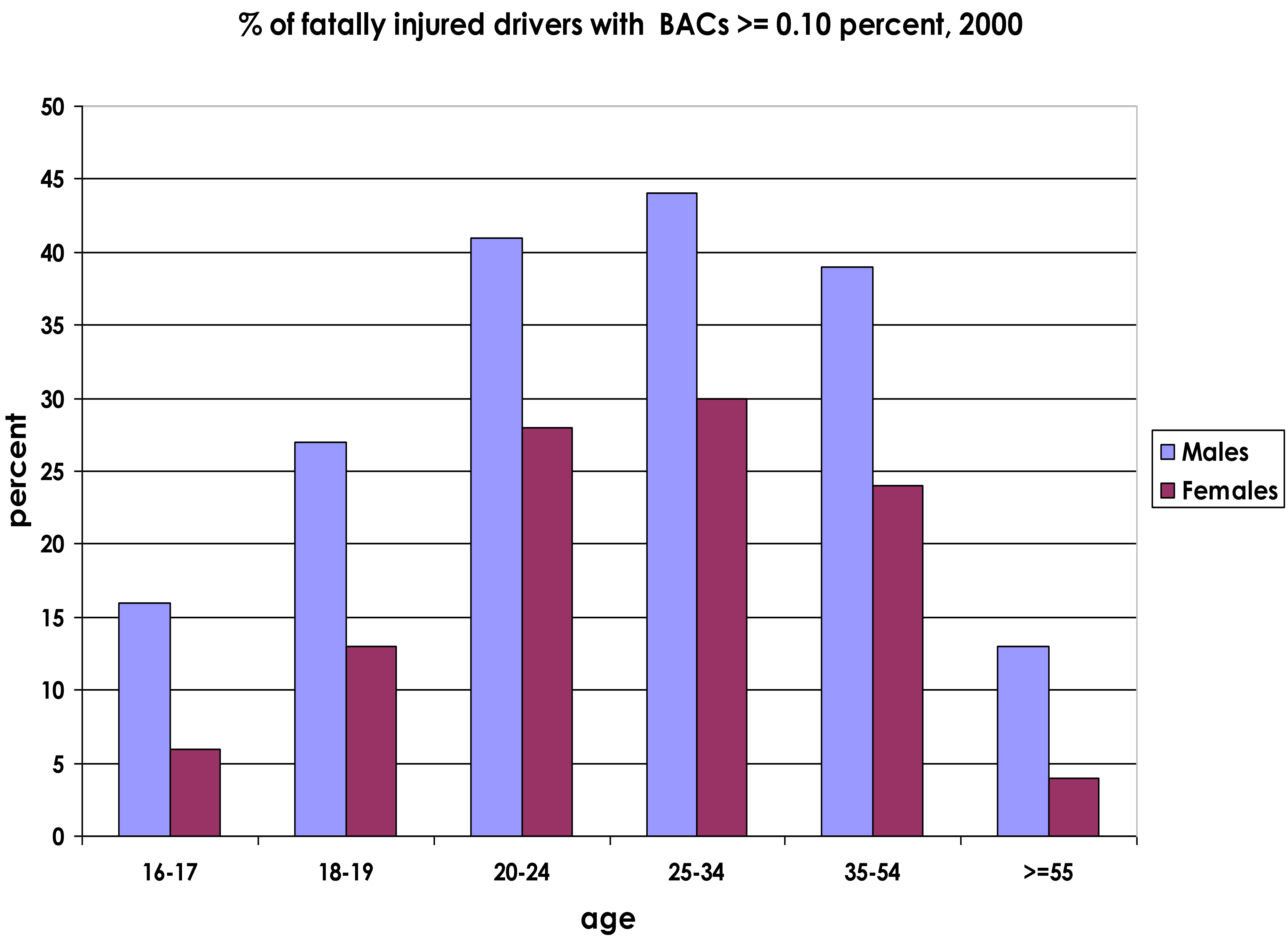
Driver deaths in crashes per million registered vehicle years

So are transportation deaths a concern in the United States?

What segment of the population is at risk?

Vehicle Deaths Percentage All Deaths by Age, 1999

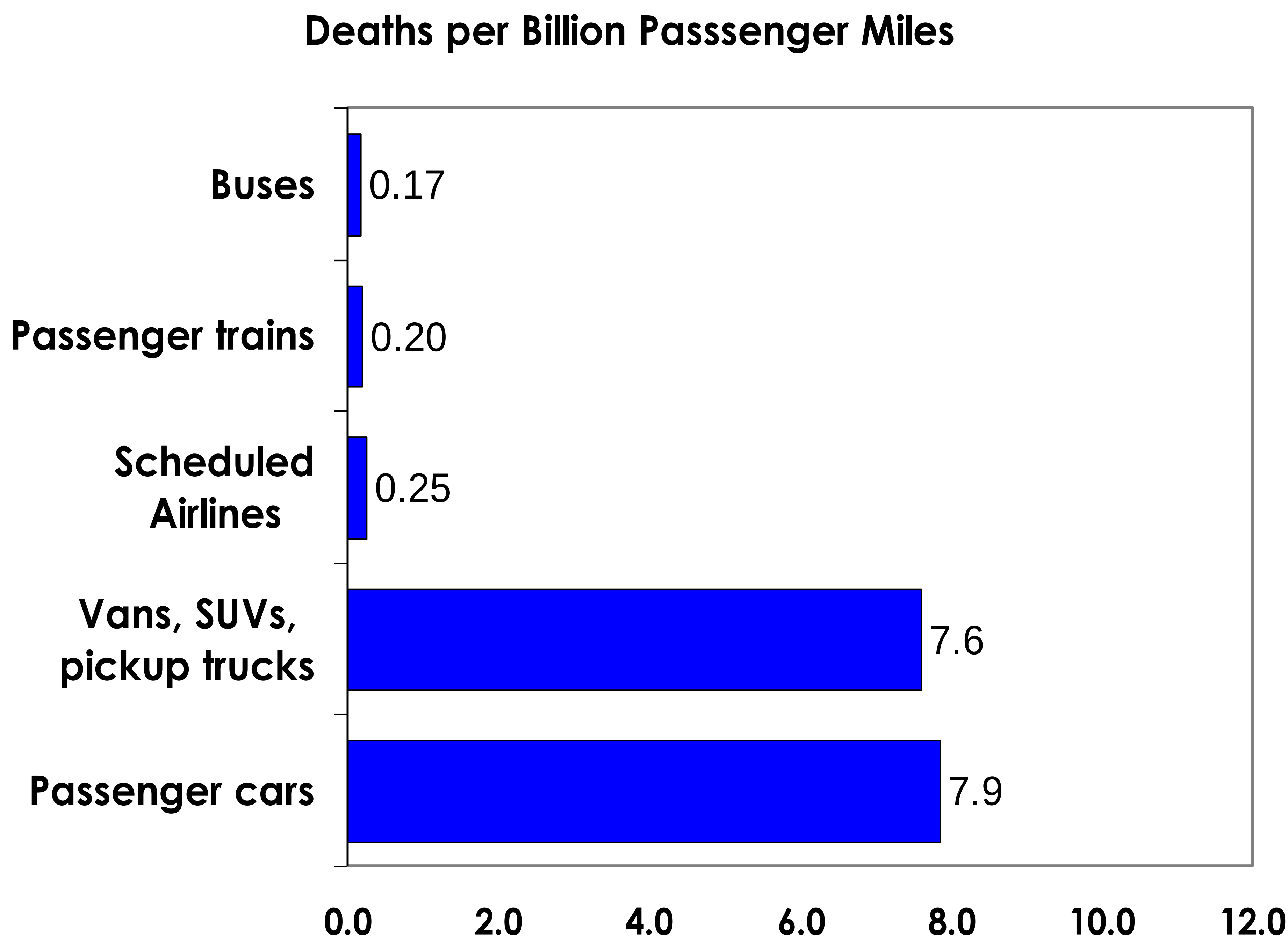



% of fatally injured drivers with BACs >= 0.10 percent, 2000
percent
50
45
40
35
30
25
20
15
10
5
0
16-17
18-19
20-24
25-34
35-54
>=55
age
Males
Females

Death Rates from Passenger Travel - 2001

	Deaths per Year	Billion Passenger Miles / Yr
Passenger cars	20,200	2,580
Vans, SUVs, pickup trucks	11,700	1,500
Scheduled Airlines	122	490
Buses	11	63
Passenger trains	3	15

*Deaths of just passengers; exclude drivers.
Statistics describe risk of being killed when a passenger.
National Safety Council Injury Facts 2003 edition.
2001 data for all but airlines which are 10-year average.


Deaths per Billion Passsenger Miles
Buses
0.17
Passenger trains
0.20
Scheduled Airlines
0.25
Vans, SUVs, pickup trucks
7.6
Passenger cars
7.9
0.0
2.0
4.0
6.0
8.0
10.0
12.0

“보행자들의 지옥… 10만 명당 5.28명 사망”

동아일보, 2007년 7월 2일

한국 보행자의 교통사고 사망 위험이 경제협력개발기구(OECD) 국가 중 최상위권인 것으로 나타났다.

녹색도시연구소(대표 임삼진 한양대 교수)가 1일 공개한 ‘2007년도 OECD 교통사고 국제비교’에 따르면 인구 10만 명당 보행자 교통사고 사망자가 한국은 5.28명으로 OECD 국가 중 1위를 기록했다.

2005년 조사에서도 한국은 인구 10만 명당 6.0명의 보행자가 교통사고로 사망해 역시 1위였다.

자동차 1만 대당 교통사고 사망자 수 역시 한국은 3.45명으로 헝가리(3.79명)에 이어 2위를 차지했다.

OECD 국가의 인구 10만 명당 보행자 교통사고 사망자 수가 평균 1.58명, 자동차 1만 대당 교통사고 사망자 수가 평균 1.68명이라는 점에 비추어 볼 때 한국은 아직 ‘교통사고 후진국’이라는 오명에서 벗어나지 못하고 있는 것.

OECD IRTAD(International Road Traffic and Accident Database)에서 자료를 받아 분석한 녹색도시연구소는 “보행자 교통안전이 가장 중요한 만큼 정부의 적극적이고 구체적인 대응이 필요하다”고 지적했다.

"보행자들의 지옥… 10만 명당 5.28명 사망" (계속)

동아일보, 2007년 7월 2일

실제로 정부가 추진한 제5차 교통안전기본계획(2002~2006년)의 부문별 목표 달성에서 가장 취약한 부문은 보행자 교통사고였다.

당초 정부의 2005년 보행자 교통사고 사망자 목표치는 1274명이었으나 실제 사망자 수는 이보다 2배 가까이 늘어난 2457명을 기록했다.

녹색도시연구소 측은 "유럽에서는 주택가 이면도로 등 생활도로는 보행자 우선권을 부여하고 차량 제한속도를 시속 20~30km로 제한하고 있다"면서 "우리나라 역시 생활도로의 제한속도를 낮추고 차량 통행을 줄이는 '교통정온화(traffic calming)' 사업을 본격적으로 추진해야 한다"고 제안했다.

한편 노인(65세 이상) 10만 명당 교통사고 사망자 수에서도 한국은 38.8명으로 OECD 국가 중 1위를 기록했고, 어린이(0~14세) 10만 명당 교통사고 사망자 수에서는 3.1명으로 4위로 나타났다.

“국내 항공사 안전불감증 여전”

SBS, 2007년 10월 23일

지난 7월 2일 김해공항에서 착륙하던 대한항공 소속 항공기의 제트엔진 역추진장치 덮개가 활주로에 떨어졌습니다.

또 지난 4월 25일에는 김해공항에서 이륙하려던 아시아나 소속 항공기가 인가되지 않은 활주로에 진입했습니다.

건설교통부에 따르면 국내 민간항공사들은 이런 안전사고로 지난해 모두 10건에 1억2천750만 원의 과징금을 부과받았습니다.

지난 2005년 사고 3건에 과징금 4천950만 원에 비해 3배 이상 크게 늘어난 것입니다.

과징금을 항공사별로 보면 아시아나항공이 4건에 9천500만 원으로 가장 많았고 대한항공이 5건에 3천만 원, 헬기업체인 럭키항공이 1건에 250만 원 순이었습니다.

올들어 지금까지 모두 8건의 사고가 발생해 현재 항공사고조사위원회의 조사를 받고 있습니다.

Is it Safer to Fly or Drive?

In attempts to soothe the nascent fear of the scheduled airline traveler, passengers waiting take-off are sometimes reminded of the cliche that they may have already completed the most dangerous part of their trip — the drive to the airport. The objective of this paper is to communicate under what conditions air travel is indeed safer than highway travel and vice versa. The conventional wisdom among risk communicators that air travel is so much safer than car travel arises from the most widely quoted death rates per billion miles for each — 0.6 for air compared to 24 for road. There are three reasons why such an unqualified comparison of aggregated fatality rates is inappropriate. First, the airline rate is passenger fatalities per passenger mile, whereas the road rate is all fatalities (any occupants, pedestrians, etc.) per vehicle mile. Second, road travel that competes with air travel is on the rural interstate system, not on average roads. Third, driver and vehicle characteristics, and driver behavior, lead to car-driver risks that vary over a wide range. Expressions derived to compare risk for drivers with given characteristics to those on airline trips of given distance showed that 40-year-old, belted, alcohol-free drivers of cars 700 pounds heavier than average are slightly less likely to be killed in 600 miles of rural interstate driving than in airline trips of the same length. Compared to this driver, 18-year-old, unbelted, intoxicated, male drivers of cars 700 pounds lighter than average have a risk over 1000 times greater. Furthermore, it is shown that the cliche above is untrue for a group of drivers having the age distribution of airline passengers.

Is it Safer to Fly or Drive?

A problem in Risk communication

L. Evans, M. C. Frick, and R. C. Schwing

General Motors Research Laboratory

June, 1990

1978-1987 had 0.55 airline passenger fatalities /billion miles

Using 1987 data, had 46,400 traffic fatalities in 1924 billion miles or

24 fatalities/billion vehicle miles

37% drivers, 18% passengers, 14% pedestrians, 9% motorcyclist and 71% of all vehicle miles by car yields

12.6 driver fatalities / billion miles

Which expect to be higher than a published value of

9.2 fatalities / billion miles

traveled for all occupants of cars.

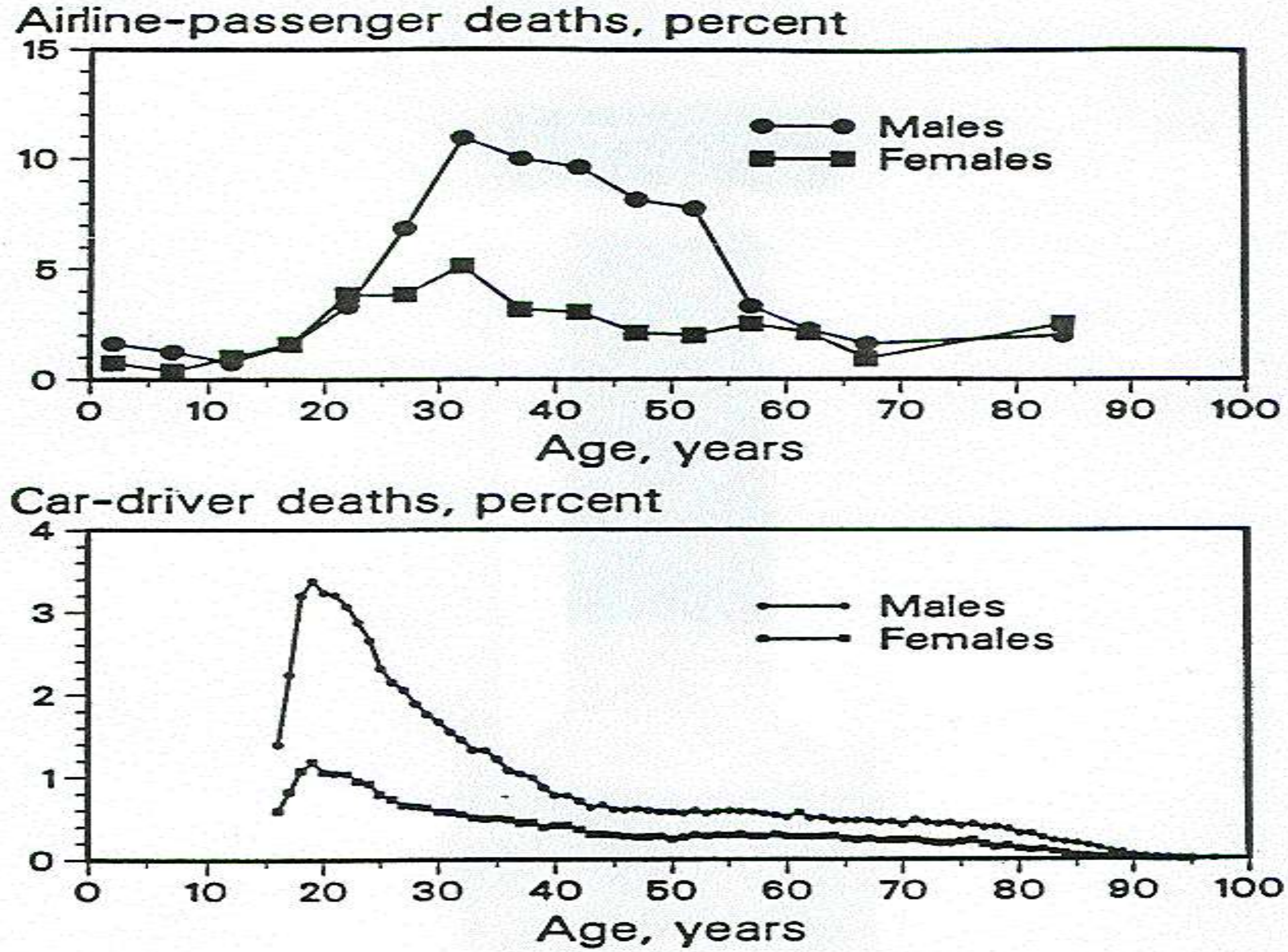


Fig. 1. Distribution by sex and age of deaths for passengers killed in air crashes (in 5-year increments) and drivers killed in car crashes (in 1-year increments). The airline data are for 809 persons killed in the 8 worst air crashes from 1975 through 1985 (the normalizing is with respect to the 759 of these aged 16 or older). The car data are for 79,220 fatally injured car drivers in the Fatal Accident Reporting System data for 1981 through 1985.

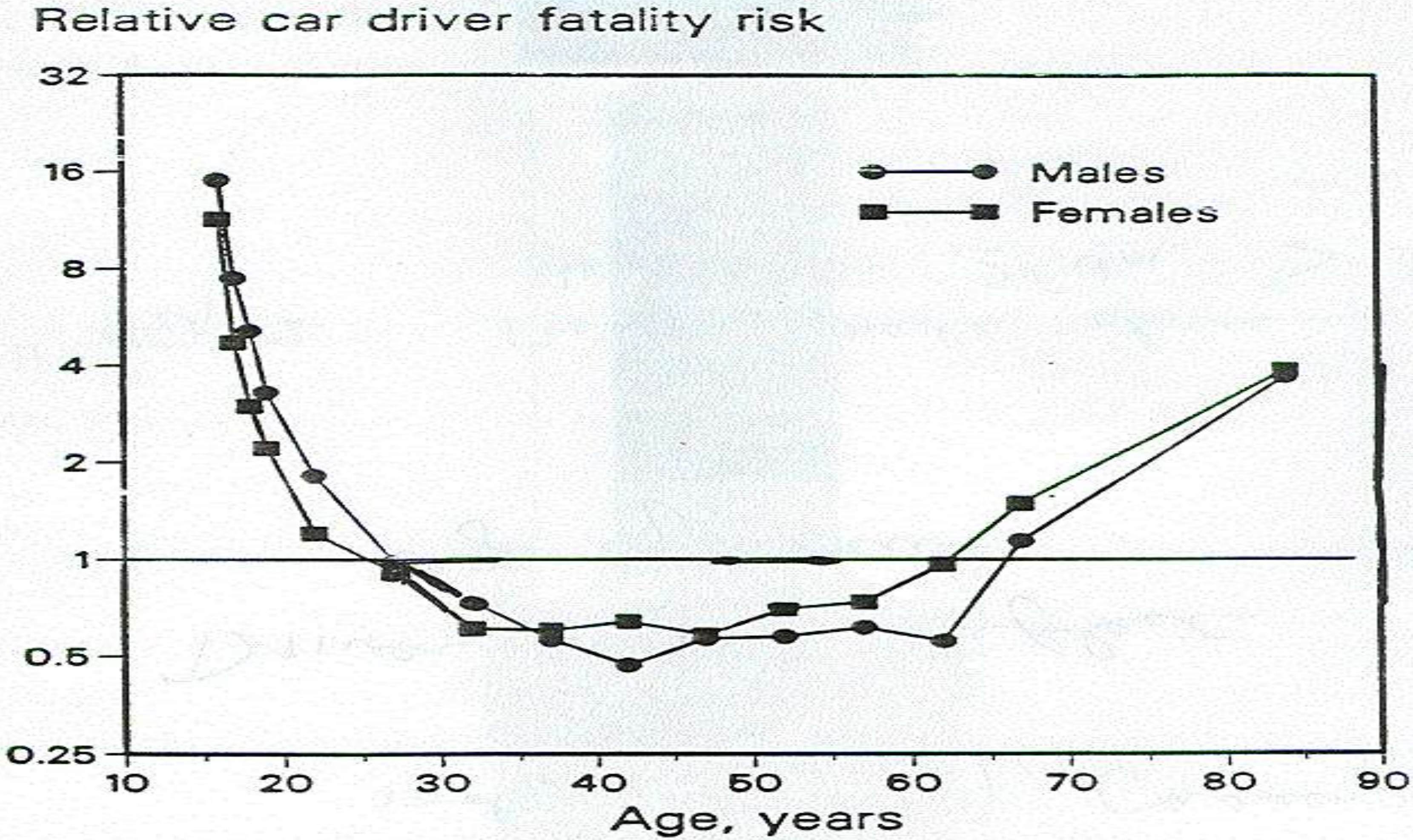


Fig. 2. Car driver fatalities per unit distance of travel relative to the average for all drivers, as indicated by the horizontal line at unity.

Auto Fatality Rate Model

Car-driver fatality rate =

$$F_{avg} \cdot M_{age} \cdot M_{alcohol} \cdot M_{seat\text{-}belt} \cdot M_{mass} \cdot M_{road\text{-}type}$$

Estimation of seat-belt fatality factor

I. Based on survival in crashes —

$$\frac{M_{seat-belts}}{M_{no-belts}} = \frac{\left[\dfrac{\text{driver-fatal crashes}}{\text{crashes}}\right]_{seat-belts}}{\left[\dfrac{\text{driver-fatal crashes}}{\text{crashes}}\right]_{no-belts}}$$

Auto Fatality Rate and Seat-Belt Effect

II. Based on fatalities per mile —

$$\frac{M_{seat-belts}}{M_{no-belts}} = \frac{\left[\dfrac{\text{driver}-\text{fatal crashes}}{\text{miles driven}}\right]_{seat-belts}}{\left[\dfrac{\text{driver}-\text{fatal crashes}}{\text{miles driven}}\right]_{no-belts}}$$

For I:

$M_{seat\text{-}belt}/M_{no\text{-}belt} = 0.7/1.2 \rightarrow 1 : 1.7$ **Only crash safety**

For II:

$M_{seat\text{-}belt}/M_{no\text{-}belt} = 0.5/1.4 \rightarrow 1 : 2.8$ **Includes other factors**

Which is more honest?

Their auto fatality model

Car-driver fatality rate =

$$F_{avg} * M_{age} * M_{alcohol} * M_{seat\text{-}belt} * M_{mass} * M_{road\text{-}type}$$

For a 40-year old, alcohol-free, belted driver, of a car 600 pounds heavier than fleet average, on a rural interstate highway:

= 12.6* 0.54 * 0.61* 0.49 * 0.73 * 0.53 = 0.8 fatalities/billion miles

For an 18-year old, intoxicated, unbelted male driver, in a car 700 pounds lighter than fleet average, on average roads:

= 12.6 * 5.10 * 7.7 * 1.4 * 1.36 * 1 = 930 fatalities/billion miles

Does it matter who is driving?

930/0.8 = 1163

Which Are Important Factors?
(Sensitivity Analysis)

Age	5.1 to 0.54	=	9.4
Alcohol	7.7 to 0.61	=	12.6
Seat Belt	1.4 to 0.49	=	2.8
Mass	1.4 to 0.73	=	1.8
Road type	1.0 to 0.53	=	1.9

AIR - Travel Safety

If average airplane trip lasts 880 miles, and experience 0.55 deaths per billion miles:

(880 miles/flight) (0.55 deaths per billion miles)
= 484 deaths per billion flights

Average fatality rate for flights of length d:
= 484 / d fatalities per billion miles
on flights of d miles

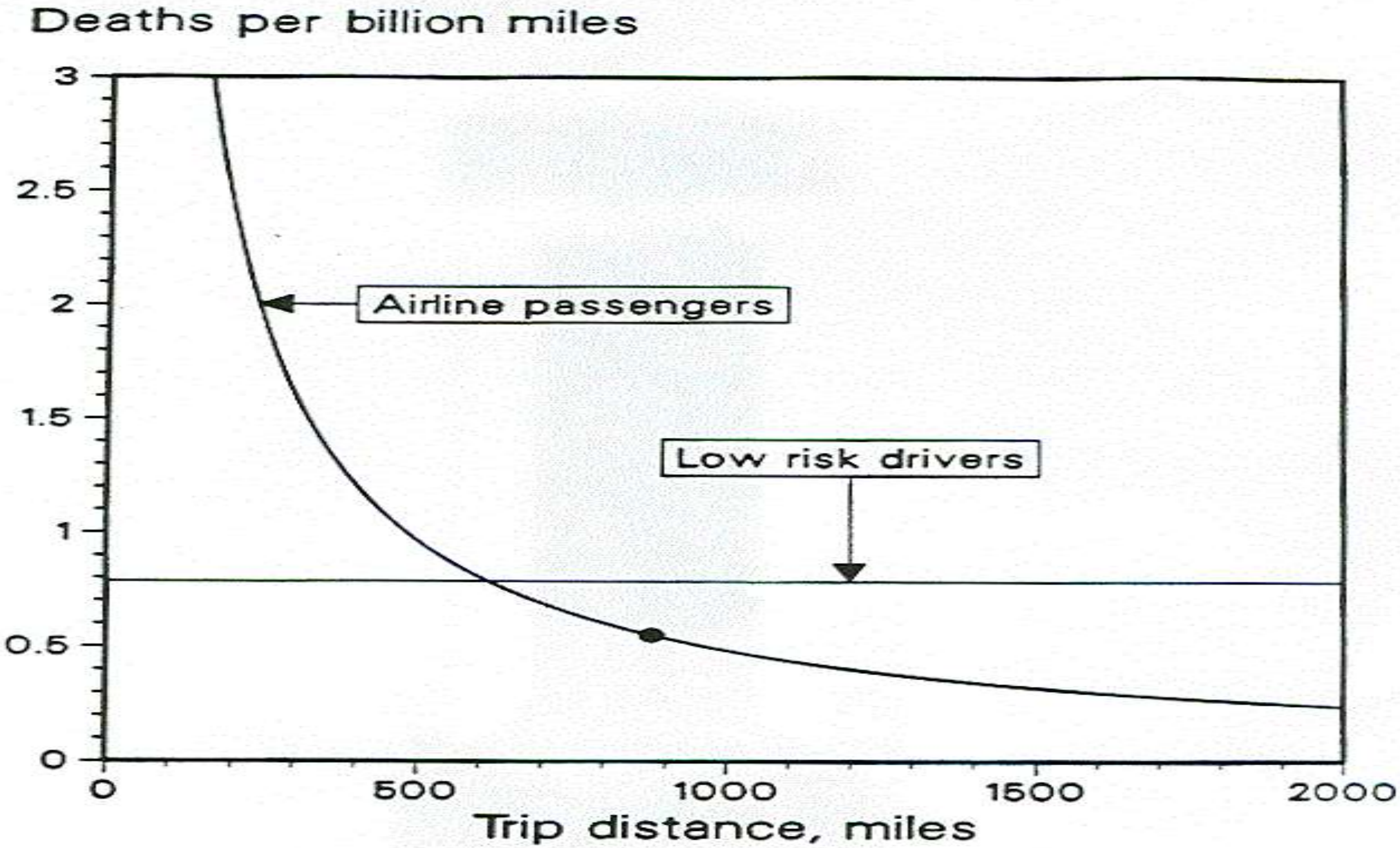


Fig. 3. The curve shows traveller fatalities per billion traveller miles for airline passengers, based on an average rate of 0.55 deaths per billion miles for a trip of average distance equal to 880 miles (indicated by the bullet on the curve). The horizontal line shows the rate for 40-year-old, belted, alcohol-free drivers travelling on the rural Interstate system in cars 700 pound heavier than average. The rate for 18-year-old, intoxicated, unbelted, male drivers travelling average roads in cars 700 pounds lighter than average (604 fatalities per billion miles) is over 200 times off-scale in this representation.

IS IT SAFER TO FLY OR DRIVE?-- A PROBLEM IN RISK COMMUNICATION

Leonard Evans, Michael C. Frick and Richard C. Schwing
Operating Sciences Department
General Motors Research Laboratories
Warren, Michigan 48090

ABSTRACT

1. 18-year-old, unbelted, intoxicated, male drivers of cars 700 pounds lighter than average are substantially more likely to be killed on the trip to the airport than on the flight.

2. Drivers with the age distribution of airline passengers are less likely to be killed on the trip to the airport than on the flight.

3. 40-year-old, belted, alcohol-free drivers of cars 700 pounds heavier than average are slightly less likely to be killed in 600 miles of rural Interstate driving than in regularly scheduled airline trips of the same length. For 300 mile trips, the driving risk is about half that for flying. Hence, for this set of drivers, car travel provides a lower fatality risk than air travel for trips in the distance range for which car and air travel are likely to be competing modes.

Barnett Comment

Analysis ignores trip length in car
Analysis ignores plane type
Death risk wrong

Claims should be 1 in 9.9 million per flight or 1 in 107
= 100 per billion flights
NOT
= 484 per billion flights used by Evans et al.

Evans uses using trips whereas Barnett is using “flight segments”

For every hour saved flying also get 67 second rise in life expectancy.

Critique

Parameter estimation ignores possible interaction among factors.

Analysis ignores trip to airport, differences in carriers, non-interstate portion of drive, differences in route lengths...

Auto risk analysis assumes a multiplicative model.

Analysis ignores nonfatal accidents which occur 70 times as frequently as fatal auto accidents, but MUCH less so for airlines.

Modeling Issues ?

Why model each factor one-at-a-time?

Why not have big regression relationship?

What are the limitations of our model?

Why did we need a model at all?

Risk Assessment & Comparison

R. Wilson and E. Crouch

"Risk assessment is a way of examining risks
so that they may be better avoided, reduced,
or otherwise managed."

Risk Estimation using Historical Data

Easy to understand and perceived as accurate

Models still required to make predictions because of trends
in age, miles traveled, exposure, technology

Only works if accidents have occurred at a sufficient rate
over sufficient time to allow estimation of their frequency

Lessons

1. Linear and multiplicative models can interpret historical data.

2. A model with independent multiplicative effects can predict accident rates for different drivers.

3. Don't believe everything you read.

Disraeli:
"There are three kinds of lies:
lies, dam lies, and statistics."

Web source: Tremendous amount of useful Information for the Traveling Public. http://www.airsafe.com

Sivak & Flannagan, *Am. Scientist, 91,* 2003

Alternative Models of Risks and Other Phenomena

- A hard question is how does one know which model is most appropriate to model different risks.
- The question is often hard because there is no clear cut answer. Decisions are often reached by subjective considerations and compromise between issues.
- Several models may appear; sometimes one model may appear to fit better than an alternative model which has better theoretical justification.
- See appendix of course packet for a discussion.