Dull, dizzy or dead: models of alcohol consumption in undergraduate teaching

Yuriy Rogovchenko

University of Agder

Seminar "**Aspects of mathematics education at technical schools and universities**"
Brno, December 7, 2015

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Injurious and harmful consequences of alcohol include

- antisocial behaviour negatively impacting health (violence, suicide and homicide, mortality due to drink-driving, criminal behaviours);

Important facts

Injurious and harmful consequences of alcohol include

- antisocial behaviour negatively impacting health (violence, suicide and homicide, mortality due to drink-driving, criminal behaviours);
- sexual and reproductive ill health (risky sexual behaviour, sexually transmitted infections including HIV, negative long-term repercussions to the foetus)

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Injurious and harmful consequences of alcohol include

- antisocial behaviour negatively impacting health (violence, suicide and homicide, mortality due to drink-driving, criminal behaviours);
- sexual and reproductive ill health (risky sexual behaviour, sexually transmitted infections including HIV, negative long-term repercussions to the foetus)
- alcohol-related disorders (alcohol dependency, liver cirrhosis and other alcohol-related liver diseases)

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Injurious and harmful consequences of alcohol include

- antisocial behaviour negatively impacting health (violence, suicide and homicide, mortality due to drink-driving, criminal behaviours);
- sexual and reproductive ill health (risky sexual behaviour, sexually transmitted infections including HIV, negative long-term repercussions to the foetus)
- alcohol-related disorders (alcohol dependency, liver cirrhosis and other alcohol-related liver diseases)
- contribution to other harmful consequences (coronary heart disease, poisoning, cancer)

norway grants eea grants ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- 2002: the WHO Regional Office for Europe established the European Information System for Alcohol and Health.

Important facts

- 2002: the WHO Regional Office for Europe established the European Information System for Alcohol and Health.
- 2007: it was decided to develop a new system of data collection and presentation for WHO and the European Commission using the same indicators.

Important facts

- 2002: the WHO Regional Office for Europe established the European Information System for Alcohol and Health.
- 2007: it was decided to develop a new system of data collection and presentation for WHO and the European Commission using the same indicators.
- 2008: the European Commission and WHO started a project to establish the European Information System on Alcohol and Health.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- 2002: the WHO Regional Office for Europe established the European Information System for Alcohol and Health.
- 2007: it was decided to develop a new system of data collection and presentation for WHO and the European Commission using the same indicators.
- 2008: the European Commission and WHO started a project to establish the European Information System on Alcohol and Health.
- 2008 and 2009: a new set of indicators were developed and data was collected among Member States on alcohol consumption, harm and responses.

norway grants eea grants ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Costs for EU

- The total tangible cost of alcohol to the European Union as it existed in 2003, has been estimated at 125 billion euro, 1.3% of the gross domestic product.

Important facts

Costs for EU

- The total tangible cost of alcohol to the European Union as it existed in 2003, has been estimated at 125 billion euro, 1.3% of the gross domestic product.
- Actual spending on alcohol-related problems accounts for 66 billion euro, while potential production not realized due to absenteeism, unemployment and premature mortality accounts for a further 59 billion.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Costs for EU

- The total tangible cost of alcohol to the European Union as it existed in 2003, has been estimated at 125 billion euro, 1.3% of the gross domestic product.
- Actual spending on alcohol-related problems accounts for 66 billion euro, while potential production not realized due to absenteeism, unemployment and premature mortality accounts for a further 59 billion.
- Aside from the mentioned tangible costs, alcohol use results in an intangible cost of between 152 and 764 billion euro.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Responses to the Alcohol and Health Survey revealed the following.

- Seventy-two per cent of countries have a clear legal definition of an alcoholic beverage.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Responses to the Alcohol and Health Survey revealed the following.

- Seventy-two per cent of countries have a clear legal definition of an alcoholic beverage.
- Sixty per cent have a written national alcohol policy; 28.9 per cent do not have a national policy in writing and 4.4 per cent have an alcohol policy in draft form only.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Responses to the Alcohol and Health Survey revealed the following.

- Seventy-two per cent of countries have a clear legal definition of an alcoholic beverage.
- Sixty per cent have a written national alcohol policy; 28.9 per cent do not have a national policy in writing and 4.4 per cent have an alcohol policy in draft form only.
- National awareness activities have taken place in 87 per cent of countries during the past three years.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Responses to the Alcohol and Health Survey revealed the following.

- Seventy-two per cent of countries have a clear legal definition of an alcoholic beverage.
- Sixty per cent have a written national alcohol policy; 28.9 per cent do not have a national policy in writing and 4.4 per cent have an alcohol policy in draft form only.
- National awareness activities have taken place in 87 per cent of countries during the past three years.
- Maximum blood alcohol levels for drivers were set at zero in 8 countries, 0.2–0.4 g/L in 9 countries, 0.5 g/L in 25 countries and 0.8 g/L in 3 countries.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Responses to the Alcohol and Health Survey revealed the following.

- Seventy-two per cent of countries have a clear legal definition of an alcoholic beverage.
- Sixty per cent have a written national alcohol policy; 28.9 per cent do not have a national policy in writing and 4.4 per cent have an alcohol policy in draft form only.
- National awareness activities have taken place in 87 per cent of countries during the past three years.
- Maximum blood alcohol levels for drivers were set at zero in 8 countries, 0.2–0.4 g/L in 9 countries, 0.5 g/L in 25 countries and 0.8 g/L in 3 countries.
- Random breath testing is done in 27 countries, and the others use selective breath testing or breath testing in the event of an accident.

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15
- Health 17

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15
- Health 17
- Absenteeism 9

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15
- Health 17
- Absenteeism 9
- Treatment/prevention 5

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15
- Health 17
- Absenteeism 9
- Treatment/prevention 5
- Unemployment 14

Important facts

The tangible cost of alcohol in the EU by cost component, in billion euro, 2003

- Traffic accidents damage 10
- Crime: damage 6, defensive 12, police 15
- Health 17
- Absenteeism 9
- Treatment/prevention 5
- Unemployment 14
- Mortality 36

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption
2. Patterns of Consumption

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption
2. Patterns of Consumption
3. Harms and Consequences

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption
2. Patterns of Consumption
3. Harms and Consequences
4. Economic Aspects

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption
2. Patterns of Consumption
3. Harms and Consequences
4. Economic Aspects
5. Alcohol Control Policies

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

A set of indicators was chosen to assess the most important aspects of the alcohol situation in WHO Member States as they relate to public health. The broad categories:

1. Levels of Consumption
2. Patterns of Consumption
3. Harms and Consequences
4. Economic Aspects
5. Alcohol Control Policies
6. Prevention, Research and Treatment

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.
- BAC or BAL is the ratio of the amount of alcohol in the blood to the amount of blood.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.
- BAC or BAL is the ratio of the amount of alcohol in the blood to the amount of blood.
- 0.1 gram of alcohol per 100 ml of blood gives a ratio of 0.1 alcohol/blood which corresponds to 0.10% concentration.

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.
- BAC or BAL is the ratio of the amount of alcohol in the blood to the amount of blood.
- 0.1 gram of alcohol per 100 ml of blood gives a ratio of 0.1 alcohol/blood which corresponds to 0.10% concentration.
- 1 drink is 1 oz (about 35 ml) of 80 proof spirit = 3 oz (about 105 ml) glass of 12% wine = 12 oz (about 420 ml) glass of 5% beer.

norway grants eea grants MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.
- BAC or BAL is the ratio of the amount of alcohol in the blood to the amount of blood.
- 0.1 gram of alcohol per 100 ml of blood gives a ratio of 0.1 alcohol/blood which corresponds to 0.10% concentration.
- 1 drink is 1 oz (about 35 ml) of 80 proof spirit = 3 oz (about 105 ml) glass of 12% wine = 12 oz (about 420 ml) glass of 5% beer.
- 1 beer = 0.6 oz (about 20 ml) alcohol = 14 grams.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Blood alcohol content (BAC), also called blood alcohol concentration, blood ethanol concentration, or blood alcohol level is most commonly used as a metric of alcohol intoxication for legal or medical purposes.
- BAC or BAL is the ratio of the amount of alcohol in the blood to the amount of blood.
- 0.1 gram of alcohol per 100 ml of blood gives a ratio of 0.1 alcohol/blood which corresponds to 0.10% concentration.
- 1 drink is 1 oz (about 35 ml) of 80 proof spirit = 3 oz (about 105 ml) glass of 12% wine = 12 oz (about 420 ml) glass of 5% beer.
- 1 beer = 0.6 oz (about 20 ml) alcohol = 14 grams.
- BAC measured by breath: BAC 0.05 means that there are 0.05 grams of alcohol per 100 ml of blood or per 2100 ml breath.

norway grants eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment

norway grants

ICELAND LIECHTENSTEIN NORWAY eea grants

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions

norway grants · ICELAND LIECHTENSTEIN NORWAY eea grants

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions
- 0.06 – 0.10% Buzzed, euphoric, increased impairment

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions
- 0.06 – 0.10% Buzzed, euphoric, increased impairment
- 0.10 – 0.20% Drunk, emotional swings, slurred speech, nausea, loss of reaction time and motor control

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions
- 0.06 – 0.10% Buzzed, euphoric, increased impairment
- 0.10 – 0.20% Drunk, emotional swings, slurred speech, nausea, loss of reaction time and motor control
- 0.20 – 0.30% Confused, nauseated, poor orientation, blackout

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions
- 0.06 – 0.10% Buzzed, euphoric, increased impairment
- 0.10 – 0.20% Drunk, emotional swings, slurred speech, nausea, loss of reaction time and motor control
- 0.20 – 0.30% Confused, nauseated, poor orientation, blackout
- 0.30 – 0.40% Possibly unconscious, unarrousable, loss of bladder function, risk of death

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

BAC Chart Values

- 0.00 – 0.03% Normal behavior, no impairment
- 0.03 – 0.06% Mild euphoria and impairment; decreased inhibitions
- 0.06 – 0.10% Buzzed, euphoric, increased impairment
- 0.10 – 0.20% Drunk, emotional swings, slurred speech, nausea, loss of reaction time and motor control
- 0.20 – 0.30% Confused, nauseated, poor orientation, blackout
- 0.30 – 0.40% Possibly unconscious, unarrousable, loss of bladder function, risk of death
- Above 0.40% Unconscious, coma, impaired breathing, risk of death

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Peak BAC is affected by

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);

norway grants · ICELAND LIECHTENSTEIN NORWAY eea grants

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).
- BAC is lower for individuals with more weight, more height, younger male.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).
- BAC is lower for individuals with more weight, more height, younger male.
- Peak BAC is attained

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).
- BAC is lower for individuals with more weight, more height, younger male.
- Peak BAC is attained
  - 30-45 minutes with empty stomach;

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).
- BAC is lower for individuals with more weight, more height, younger male.
- Peak BAC is attained
  - 30-45 minutes with empty stomach;
  - 60-90 minutes after a meal.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- Peak BAC is affected by
  - consumption (amount, concentration, time period, personal habits, medical condition);
  - body factors (gender, height, weight, stomach content, age (males)).
- BAC is lower for individuals with more weight, more height, younger male.
- Peak BAC is attained
  - 30-45 minutes with empty stomach;
  - 60-90 minutes after a meal.
- Legal limit in Norway and Sweden is 0.02%, in Denmark, Finland and Iceland 0.05%, in Czech Republic 0%.

Important facts

- 20-25% of alcohol is absorbed through the stomach.

Important facts

- 20-25% of alcohol is absorbed through the stomach.
- 75-80% of alcohol is absorbed through the small intestine.

Important facts

- 20-25% of alcohol is absorbed through the stomach.
- 75-80% of alcohol is absorbed through the small intestine.
- Elimination of alcohol:

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

- 20-25% of alcohol is absorbed through the stomach.
- 75-80% of alcohol is absorbed through the small intestine.
- Elimination of alcohol:
    - 95% metabolized by liver;

Important facts

- 20-25% of alcohol is absorbed through the stomach.
- 75-80% of alcohol is absorbed through the small intestine.
- Elimination of alcohol:
  - 95% metabolized by liver;
  - 5% expelled through breath and other bodily functions;

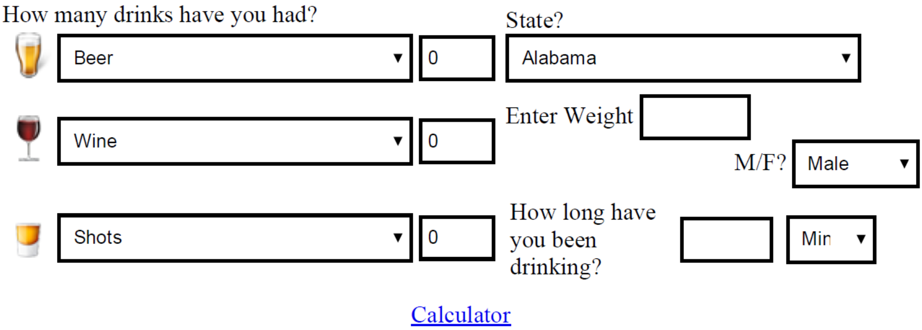
Important facts

- 20-25% of alcohol is absorbed through the stomach.
- 75-80% of alcohol is absorbed through the small intestine.
- Elimination of alcohol:
  - 95% metabolized by liver;
  - 5% expelled through breath and other bodily functions;
  - healthy liver metabolizes about 0.5 oz (17 ml) of alcohol per hour.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Important facts

Interactive models on the web (http://bloodalcoholcalculator.org/)



norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- In the obligatory Matlab lab for the second year students in Differential Equations course at the Umeå University in Sweden I suggested as one of the tasks case study “dull (0.05), dizzy (0.15) or dead (0.40)?” adopted from the book “Drugs, Society and Human Behavior” by Oakley and Ksir (1993).

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- In the obligatory Matlab lab for the second year students in Differential Equations course at the Umeå University in Sweden I suggested as one of the tasks case study "dull (0.05), dizzy (0.15) or dead (0.40)?" adopted from the book "Drugs, Society and Human Behavior" by Oakley and Ksir (1993).
- The system of differential equations is used to analyze the concentrations $C_1(t)$ and $C_2(t)$ of alcohol (effective BAL) at time t in the gastrointestinal tract and in the bloodstream respectively with Michaelis-Menten type function,

$$\frac{\mathrm{d}C_1}{\mathrm{d}t} = I - k_1 C_1, \qquad C_1(0) = C_0,$$
$$\frac{\mathrm{d}C_2}{\mathrm{d}t} = k_2 C_1 - \frac{k_3 C_2}{C_2 + M}, \qquad C_2(0) = 0.$$

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.
- Non-documented informal feedback from students and observations:

norway grants eea grants ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.
- Non-documented informal feedback from students and observations:
  - although the task was more demanding, most students liked it (especially biology students);

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.
- Non-documented informal feedback from students and observations:
  - although the task was more demanding, most students liked it (especially biology students);
  - due to practical usefulness, this task was preferred to a similar task on modeling the dynamics of the aged-structured population;

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.
- Non-documented informal feedback from students and observations:
  - although the task was more demanding, most students liked it (especially biology students);
  - due to practical usefulness, this task was preferred to a similar task on modeling the dynamics of the aged-structured population;
  - better students submitted detailed reports, designed own codes and arranged non-standard presentation of graphics;

norway grants ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Personal teaching experience

- The task included individual computations for binge and continuous drinking on empty stomach ($k_1 = k_2$, $I = 0$) with a prescribed number of drinks per hour, as well as binge and continuous drinking after a substantial meal.
- Non-documented informal feedback from students and observations:
  - although the task was more demanding, most students liked it (especially biology students);
  - due to practical usefulness, this task was preferred to a similar task on modeling the dynamics of the aged-structured population;
  - better students submitted detailed reports, designed own codes and arranged non-standard presentation of graphics;
  - weaker students did not particularly like the task and had troubles with it.

Simple models to explore

- One of the simplest (if not the simplest) alcohol-related models illustrates the relationship between the relative risk R of having a car accident and the blood alcohol level b,

$$\frac{\mathrm{d}R}{\mathrm{d}b} = kR, \qquad R(0) = 1.$$

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Simple models to explore

- One of the simplest (if not the simplest) alcohol-related models illustrates the relationship between the relative risk R of having a car accident and the blood alcohol level b,

$$\frac{\mathrm{d}R}{\mathrm{d}b} = kR, \qquad R(0) = 1.$$

- A positive constant k is determined using the police statistics ($R = 20\%$ for $b = 0.14$), which gives a reasonably good approximation.

norway grants
eea grants
ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Simple models to explore

- One of the simplest (if not the simplest) alcohol-related models illustrates the relationship between the relative risk R of having a car accident and the blood alcohol level b,

$$\frac{\mathrm{d}R}{\mathrm{d}b} = kR, \qquad R\left(0\right) = 1.$$

- A positive constant k is determined using the police statistics ($R = 20\%$ for $b = 0.14$), which gives a reasonably good approximation.
- Limitation: R increases beyond 100% as b increases.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Simple models to explore

- One of the simplest (if not the simplest) alcohol-related models illustrates the relationship between the relative risk R of having a car accident and the blood alcohol level b,

$$\frac{\mathrm{d}R}{\mathrm{d}b} = kR, \qquad R(0) = 1.$$

- A positive constant k is determined using the police statistics ($R = 20\%$ for $b = 0.14$), which gives a reasonably good approximation.
- Limitation: R increases beyond 100% as b increases.
- However, this corresponds to somewhat like 12 drinks (35 ml each) of 80% proof whiskey for a man weighting about 72.5 kg within 2 hours after a meal.

norway grants eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

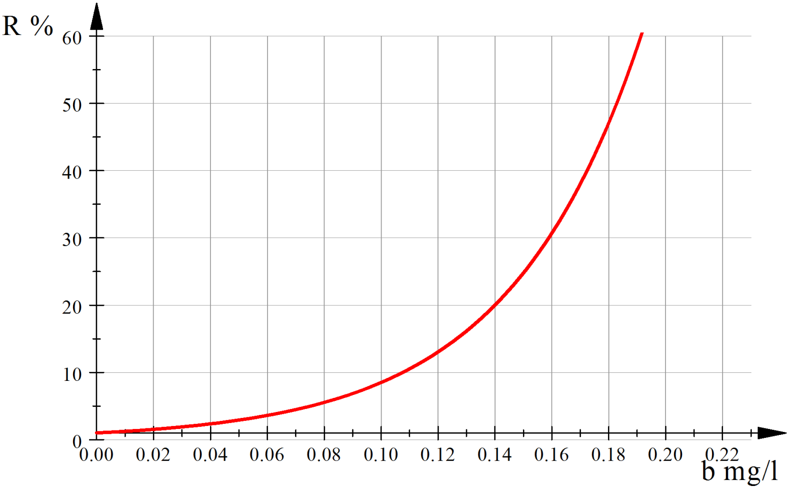
Simple models to explore

- One of the simplest (if not the simplest) alcohol-related models illustrates the relationship between the relative risk R of having a car accident and the blood alcohol level b,

$$\frac{\mathrm{d}R}{\mathrm{d}b} = kR, \qquad R(0) = 1.$$

- A positive constant k is determined using the police statistics ($R = 20\%$ for $b = 0.14$), which gives a reasonably good approximation.
- Limitation: R increases beyond 100% as b increases.
- However, this corresponds to somewhat like 12 drinks (35 ml each) of 80% proof whiskey for a man weighting about 72.5 kg within 2 hours after a meal.
- "Responsible" drinking with the BAL below 0.05 corresponds roughly to three shots.

Risk versus BAL



MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- Splitting the alcohol consumption into two phases.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- Splitting the alcohol consumption into two phases.
- Here A is the blood alcohol concentration, I is the amount of alcohol consumed divided by gender ratio b times amount of body water per weight times the duration T of the alcohol consumption period, α is a liver function parameter, β is a kidney function parameter, ν is the gender parameter.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- Splitting the alcohol consumption into two phases.
- Here A is the blood alcohol concentration, I is the amount of alcohol consumed divided by gender ratio b times amount of body water per weight times the duration T of the alcohol consumption period, α is a liver function parameter, β is a kidney function parameter, ν is the gender parameter.
- Drinking phase:

$$\frac{\mathrm{d}A}{\mathrm{d}t} = I - \frac{\alpha A}{A + \beta^{\nu}}, \qquad 0 \le t \le T, \qquad A(0) = 0,$$

equation is used to determine the peak alcohol concentration M which is assumed to occur at the end of the alcohol consumption period, $M = A(T)$.

norway grants · ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (2-phase model)

- A good approximation for large values of T, although the peak concentration actually occurs 30-45 minutes after the last drink was consumed.

Further explorations (2-phase model)

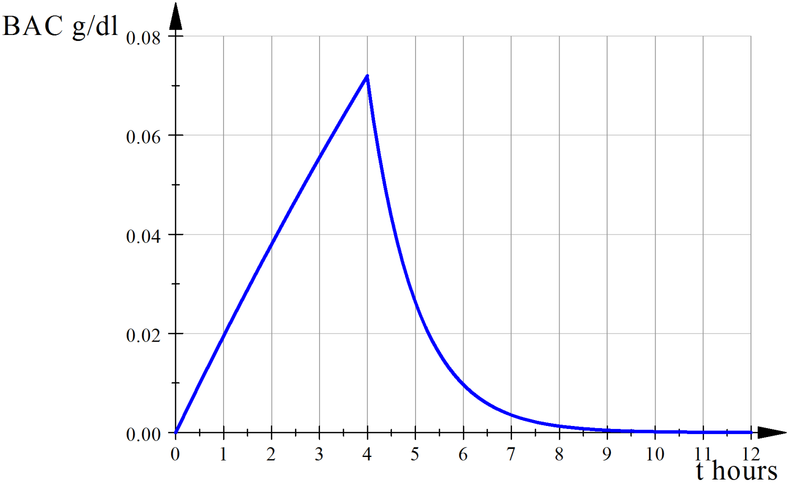
- A good approximation for large values of T, although the peak concentration actually occurs 30-45 minutes after the last drink was consumed.
- Recovery phase:

$$\frac{\mathrm{d}A}{\mathrm{d}t} = -\frac{\alpha A}{A + \beta^{\nu}}, \qquad t > T, \qquad A(T) = M,$$

equation is used to determine the instant t_* when BAC falls below the legal limit (or other prescribed limit).

norway grants · ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (2-phase model)



MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (2-compartmental model)

- A simple model for the concentration A of the alcohol in the stomach and concentration B of alcohol in the blood consists of two differential equations

$$\frac{\mathrm{d}A}{\mathrm{d}t} = -k_1 A,$$
$$\frac{\mathrm{d}B}{\mathrm{d}t} = k_1 A - k_2 B,$$

where rate law constants k_1 and k_2 can be determined by fitting the experimental data so that the mean absolute error is minimized.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (2-compartmental model)

- A simple model for the concentration A of the alcohol in the stomach and concentration B of alcohol in the blood consists of two differential equations

$$\frac{\mathrm{d}A}{\mathrm{d}t} = -k_1 A,$$
$$\frac{\mathrm{d}B}{\mathrm{d}t} = k_1 A - k_2 B,$$

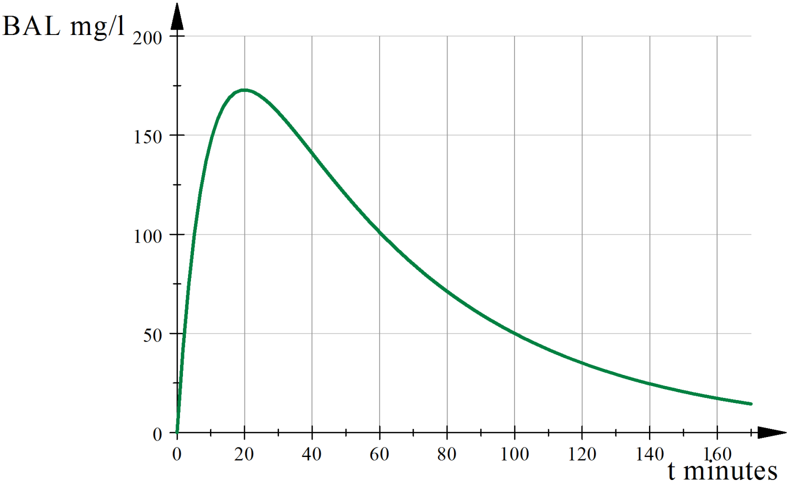
where rate law constants k_1 and k_2 can be determined by fitting the experimental data so that the mean absolute error is minimized.

- Due to simplicity of the system, it can be integrated directly yielding an explicit formula for the alcohol concentration in the blood,

$$B(t) = A_0 \frac{k_1}{k_2 - k_1} \left(\exp(-k_1 t) - \exp(-k_2 t)\right).$$

norway grants | ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (2-compartmental model)



Further explorations (fitting the data)

- Least square data fitting can be done using a given set of real data. A reasonably good choice (still coming as solutions of differential equations) could be, for instance a function of the form

Further explorations (fitting the data)

- Least square data fitting can be done using a given set of real data. A reasonably good choice (still coming as solutions of differential equations) could be, for instance a function of the form
  - $$f_1(t) = a\left(1 - e^{-ct}\right)$$

    or

Further explorations (fitting the data)

- Least square data fitting can be done using a given set of real data. A reasonably good choice (still coming as solutions of differential equations) could be, for instance a function of the form
  - $$f_1\left(t\right) = a\left(1 - e^{-ct}\right)$$

  or
  - $$f_2\left(t\right) = a\left(1 - e^{-ct}\right) + bt,$$

  where three parameters a, b, and c should be selected to fit the experimental data the best way possible.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations (fitting the data)

- Least square data fitting can be done using a given set of real data. A reasonably good choice (still coming as solutions of differential equations) could be, for instance a function of the form
  - $$f_1(t) = a\left(1 - e^{-ct}\right)$$

  or
  - $$f_2(t) = a\left(1 - e^{-ct}\right) + bt,$$

  where three parameters a, b, and c should be selected to fit the experimental data the best way possible.
- This is achieved by minimizing the sum of squares of the form

$$S(t) = \sum_{i=1}^{n} \left(d_i(t_i) - f_i(t_i)\right),$$

where $d_i(t_i)$ are taken from the given data set.

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- One can model alcohol consumption behavior as "infectious disease" dealing with a system of four nonlinear differential equations and dividing population into four different classes, namely

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- One can model alcohol consumption behavior as "infectious disease" dealing with a system of four nonlinear differential equations and dividing population into four different classes, namely
  - moderate and occasional drinkers with drinking frequency $S(t)$;

norway grants eea grants ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- One can model alcohol consumption behavior as "infectious disease" dealing with a system of four nonlinear differential equations and dividing population into four different classes, namely
  - moderate and occasional drinkers with drinking frequency $S(t)$;
  - heavy drinkers with drinking frequency $D(t)$;

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- One can model alcohol consumption behavior as “infectious disease” dealing with a system of four nonlinear differential equations and dividing population into four different classes, namely
  - moderate and occasional drinkers with drinking frequency $S(t)$;
  - heavy drinkers with drinking frequency $D(t)$;
  - drinkers in treatment with drinking frequency $T(t)$;

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- One can model alcohol consumption behavior as "infectious disease" dealing with a system of four nonlinear differential equations and dividing population into four different classes, namely
  - moderate and occasional drinkers with drinking frequency $S(t)$;
  - heavy drinkers with drinking frequency $D(t)$;
  - drinkers in treatment with drinking frequency $T(t)$;
  - temporarily recovered class of drinkers with drinking frequency $R(t)$.

norway grants
eea grants
ICELAND LIECHTENSTEIN NORWAY
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- A similar but simpler model using a system of three nonlinear differential equations can be derived for the society which is split into three groups

Further explorations

- A similar but simpler model using a system of three nonlinear differential equations can be derived for the society which is split into three groups
  - potential drinkers $P(t)$;

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- A similar but simpler model using a system of three nonlinear differential equations can be derived for the society which is split into three groups
  - potential drinkers $P(t)$;
  - current drinkers $D(t)$;

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- A similar but simpler model using a system of three nonlinear differential equations can be derived for the society which is split into three groups
  - potential drinkers $P(t)$;
  - current drinkers $D(t)$;
  - individuals who permanently quit drinking $Q(t)$.

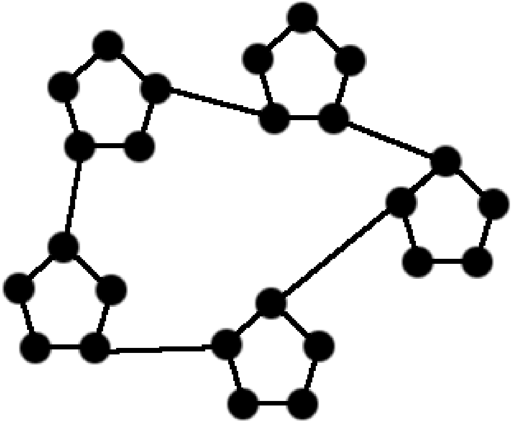
Further explorations

- Choosing u as the probability for an individual to be involved in alcohol related problems, one may consider a logistic-like model governing the dynamics of u and capturing the spread or persistence of drinking habits in a society in relation to the society structure, like

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

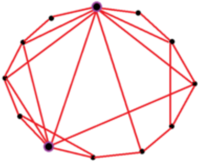
- Choosing u as the probability for an individual to be involved in alcohol related problems, one may consider a logistic-like model governing the dynamics of u and capturing the spread or persistence of drinking habits in a society in relation to the society structure, like
- connected-cavemen

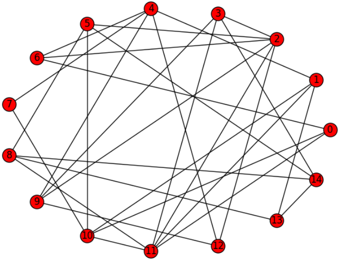


MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- small world and random





Further explorations

- Mathematically, the system of equations is

$$u_i' = u_i\left(1 - u_i\right)\left(r \deg i - A\left(i;*\right) u_i\right),$$

where

Further explorations

- Mathematically, the system of equations is

$$u_i' = u_i\,(1 - u_i)\,(r \deg i - A\,(i;*)\,u_i)\,,$$

where

  - *r* is a threshold value which measures individual's resistance to external influence,

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Further explorations

- Mathematically, the system of equations is

$$u_i' = u_i\,(1 - u_i)\,(r \deg i - A\,(i;*)\,u_i)\,,$$

where

  - r is a threshold value which measures individual's resistance to external influence,
  - $\deg i$ denotes the degree of a node i, i.e., the number of people that individual i has relation with, and

Further explorations

- Mathematically, the system of equations is

$$u_i' = u_i\,(1 - u_i)\,(r \deg i - A\,(i;*)\,u_i)\,,$$

  where

  - r is a threshold value which measures individual's resistance to external influence,
  - $\deg i$ denotes the degree of a node i, i.e., the number of people that individual i has relation with, and
  - $A\,(i;*)$ is the i-th column of the adjacency matrix A whose entry $A\,(i,j) = 1$ if individuals i and j know each other.

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

From student projects to research

- 2006 Graduate Student Mathematical Modeling Camp at Rensselaer Polytechnic Institute, Troy, NY, "Modeling Alcohol Problems with Structured Populations" (random networks)

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

From student projects to research

- 2006 Graduate Student Mathematical Modeling Camp at Rensselaer Polytechnic Institute, Troy, NY, "Modeling Alcohol Problems with Structured Populations" (random networks)
- Dennis Oswald, Lindsay Walton, Jessika York, and Michał Kowalczyk, "Modeling Alcohol Consumption Behaviors at Kent State University" (nonlinear system of 3 DEs)

From student projects to research

- 2006 Graduate Student Mathematical Modeling Camp at Rensselaer Polytechnic Institute, Troy, NY, "Modeling Alcohol Problems with Structured Populations" (random networks)
- Dennis Oswald, Lindsay Walton, Jessika York, and Michał Kowalczyk, "Modeling Alcohol Consumption Behaviors at Kent State University" (nonlinear system of 3 DEs)
- Chris Ludwin, University of South Florida, "Blood Alcohol Content", Undergraduate Journal of Mathematical Modeling: One + Two, Volume 3, Issue 2, Article 1,Spring 2011 (integrable system of 2 DEs)

From student projects to research

- 2006 Graduate Student Mathematical Modeling Camp at Rensselaer Polytechnic Institute, Troy, NY, "Modeling Alcohol Problems with Structured Populations" (random networks)
- Dennis Oswald, Lindsay Walton, Jessika York, and Michał Kowalczyk, "Modeling Alcohol Consumption Behaviors at Kent State University" (nonlinear system of 3 DEs)
- Chris Ludwin, University of South Florida, "Blood Alcohol Content", Undergraduate Journal of Mathematical Modeling: One + Two, Volume 3, Issue 2, Article 1,Spring 2011 (integrable system of 2 DEs)
- Andrew Abbate, Kevin McCarthy, and Rona Wilf, "Multi-Compartmental Model for Blood Concentration of Ethanol and Acetaminophen over Time", BMES 546 Fall 2013 (5 compartmental model)

norway grants
ICELAND LIECHTENSTEIN NORWAY eea grants
MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

From student projects to research

- Francisco-José Santonja, Emilio Sánchez, María Rubio, and José-Luis Morera, Alcohol consumption in Spain and its economic cost: A mathematical modeling approach, *Mathematical and Computer Modelling*, Vol. 52 (2010), pp. 999-1003

From student projects to research

- Francisco-José Santonja, Emilio Sánchez, María Rubio, and José-Luis Morera, Alcohol consumption in Spain and its economic cost: A mathematical modeling approach, *Mathematical and Computer Modelling*, Vol. 52 (2010), pp. 999-1003
- Claver Pedzisai Bhunu, A mathematical analysis of alcoholism, *World Journal of Modelling and Simulation*, Vol. 8 (2012), pp. 124-134

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

From student projects to research

- Francisco-José Santonja, Emilio Sánchez, María Rubio, and José-Luis Morera, Alcohol consumption in Spain and its economic cost: A mathematical modeling approach, *Mathematical and Computer Modelling,* Vol. 52 (2010), pp. 999-1003
- Claver Pedzisai Bhunu, A mathematical analysis of alcoholism, *World Journal of Modelling and Simulation*, Vol. 8 (2012), pp. 124-134
- Swarnali Sharma and G.P. Samanta, Drinking as an epidemic: a mathematical model with dynamic behaviour, *J. Appl. Math. & Informatics*, Vol. 31 (2013), pp. 1-25

MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Thank you for your attention!

I hope you enjoyed my presentation...