Public Health Consequences

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Health depends on

Exposure to agents / stressors
- Physical, chemical, biological, social

Behavior
- Avert exposure (primary prevention)
- Mitigate effects of exposure (secondary prevention)
- Ability to avert/mitigate may depend on income, information, other resources

Food production / distribution / consumption can affect both exposure & behavior
- Constituents & contaminants in specific foods
- Diet (portfolio of foods)
- Disposable income (diverse health risks)
Risk assessment

Exposure

- Pathways: food, air, water
- Quantity in food may depend on handling, preparation (especially for biological agents)

Exposure-response function

- Epidemiology
- Animal bioassays (for pesticides)

Valuation

- Aggregating multiple health effects
- Monetary values, QALYs (quality-adjusted life years)
Major pathways (?)

Production & processing
- Nutrients, contaminants, pesticides (chemical, biological)
- Waste streams from facilities
- Energy

Packaging
- Contaminants (but packaging is protective)
- Energy

Distribution
- Energy

Preparation
- Nutrients, contaminants
- Energy (refrigeration is 14% of 2001 residential electricity, EIA)

Consumption
- Nutrients, contaminants, pesticides
- Diet
Antibiotic resistance

Shifting ecology of hazardous microbes toward resistant strains reduces efficacy of treatment when infected

- Environmental effect
- Independent of production & consumption of specific foods (?)

Analysis

- Distribution of strains
- Chance of infection by strain from all pathways
Analyzing health effects

Diet
Nutrients, contaminants, pesticides
Energy
Waste streams
Diet

Affects risk of many diseases & health effects
  – Cardiovascular, cancer, diabetes, …
  – Obesity (direct concern, may be important intermediary)
  – Birth outcomes
  – Information source: epidemiology

Affected by many factors
  – Prices, convenience (availability / distribution, preparation)
  – Information
  – Traditions / customs (social / religious / ethnic)
  – Information source: economics (demand systems, information)
Nutrients, contaminants, pesticides (chemical, biological)

Affect health positively / adversely
Nutrients may have hormetic effects
  – Positive intake beneficial, excessive intake harmful
Contaminants & pesticides never beneficial (?), may have safe thresholds (?)

Information source: epidemiology, toxicology
  – Dose-response function often unknown / unreported
    • Recommended Dietary Allowance (RDA) / Dietary Reference Intake (DRI)
    • How large is change in risk from crossing threshold?
    • What is effect of changing intake without crossing threshold?
  – Nonlinear dose-response (threshold, hormetic)
    • Effect of changing intake depends on level
Energy

All stages use commercial energy
  – Add post-consumption clean-up stage?
More important for production & processing, packaging, distribution (?)
Exposure pathway: environmental release & exposure
Fossil-fuel combustion
  – From electricity production, transport, farm vehicles, …
  – Air emissions: fine particulate matter (PM), PM & ozone precursors
  – Life-cycle fuel production
  – Information source: epidemiology, fate, transport & exposure modeling
Waste streams

Livestock
Fertilizer & pesticide runoff

Exposure pathways
  - Air emissions
  - Water (drinking, bathing, swimming)
  - Food contamination
    • Bacteria from livestock waste

Information source: epidemiology, toxicology, fate, transport & exposure modeling
Non-economic behavior

Is focus on externalities or consequences?
  – How define externality when behavior departs from economic model?
Is focus on externalities because outcomes would otherwise be efficient?

Other non-market influences
  – Information asymmetry
    • Dietary guidelines, labels
    • Social networks
Are health risks from poor diet internalized?
  – Time inconsistency, limited self-control
    • Eat better, lose weight tomorrow
    • Restrict marketing to children?
Valuing health effects: standard metrics

Willingness to pay (WTP)
- Willingness to accept compensation (WTA)
- Widely used in environmental and transportation applications

Health utility measures
- Quality adjusted life years (QALYs)
- Disability adjusted life years (DALYs)
- Widely used in public health and medical applications
Consistency with individual preferences?

QALYs
- Structure imposed
- Several conditions—reasonable on average but often violated
  - Inconsistency with individual preferences known from the start
- Depends only on “health”

WTP
- Less structured, less constrained
- More susceptible to fuzzy thinking
- Can incorporate other effects, including voluntary attributes
Willingness to Pay

Rate of substitution between (health and longevity) and wealth / income

Value per statistical life (VSL)
Wealth v. mortality risk

![Graph showing the relationship between wealth and survival probability. The graph demonstrates an indifference curve that illustrates the trade-off between wealth and the probability of survival. The x-axis represents survival probability ( = 1 – risk), ranging from 0 to 1, and the y-axis represents wealth, with values decreasing as survival probability increases.](image-url)
Wealth v. mortality risk

\[ VSL \approx \frac{WTP}{\Delta r} \]
Wealth v. mortality risk

\[ VSL \approx \frac{WTP}{\Delta r} \approx \frac{WTA}{\Delta r} \]

- **Wealth**
- **Survival probability ( = 1 – risk)**

Diagram showing an indifference curve with WTA and WTP points.
VSL = slope (local)
VSL and units

Concept is rate of tradeoff between money and risk
- VSL: normalized to $\Delta r = 1$
- Micromort: normalized to $\Delta r = 1 / \text{million}$

Like measuring speed in km/hr, m/s
- Cannot extrapolate from instantaneous speed to distance traveled over a long time
Value per statistical life

Is NOT a measure of the intrinsic worth of an individual

Does NOT measure what an individual would pay to avoid certain death (or accept as compensation for certain death)

Depends on
  – (total) baseline risk
  – income and wealth

May depend on other characteristics of risk
  – e.g., acute trauma or chronic disease
  – “voluntary” or “involuntary”

May depend on social, cultural, economic factors
Quality-adjusted life years
Health profile

\[ q = \text{utility of health state} \]
Health profile

$\text{Increase in QALYs}$
Quality-adjusted life years

Tradeoff between health and longevity
Value of a health profile = number of QALYs
Value of change in health risk = change in $E(\text{QALYs})$
Tradeoffs between health and longevity implicitly assumed to be independent of wealth
Does not address tradeoff between (health and longevity) and other goods
  – Need to determine “threshold cost-effectiveness ratio” or “monetary value per QALY” in some other way
Quality-adjusted life years

Constant health state

Time-varying health states

\[ QALYs = qT \]

\[ QALYs = \sum_{i=1}^{N} q_i T_i \]

\[ q = "Health-related quality of life" \text{ (HRQL)} \]

\[ 0 \leq q \leq 1 \]

\[ q < 0 \text{ for health states worse than death} \]

\[ T = \text{duration} \]
Assumptions underlying QALYs

Constant health state (Pliskin, Shepard, & Weinstein, 1980)

1. Mutual utility independence
2. Constant proportional tradeoff of longevity for health
3. Risk neutrality over lifespan

For time-varying health states

4. Additive independence of health states over time
Interpersonal comparison

Evaluate policy by summing individual changes in QALYs or WTP

To add utility across people, need some method to standardize it
  – Who benefits more from an extra year of life?

Neoclassical economics assumes utility cannot be measured, compared between people

Any standard we choose is arbitrary
  – QALYs: healthy year of life
  – WTP: purchasing power
## Conceptual summary

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