PROBABILITY, PERSONALIZATION, AND RISK IN MEDICAL AI

CS109

KATIE CREEL
VAGINAL BIRTH AFTER CESAREAN

Maternal age (range 15-50 years):

The information on this website describes the outcome vaginal birth after cesarean (VBAC) in a term pregnancy for a population of individuals who received care at the hospitals within the NICHD MFMU Network between 1999 and 2002. Specifically, using the MFMU Network Cesarean Registry\(^1\) data, individuals were included if they were 1) delivered at term (on or after 37 weeks 0 days) with a live single fetus at the time of labor and delivery admission, 2) had a trial of labor after cesarean, and 3) had history of one prior cesarean delivery. For more details, see the article "Prediction of vaginal birth after cesarean delivery: a collaborative study of United States hospital data from the Multicenter Fetal Medicine Units Network."
CALCULATORS WITHOUT MACHINE LEARNING FUNCTION AS A BLACK BOX ... WITH KNOWN INPUTS
VBAC INCLUSIONS

- Maternal Age
- Height, Pre-Pregnancy Weight
- Previous VBAC
  - Arrest disorder indication for prior cesarean?
- Treated for Chronic Hypertension?
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VBAC INCLUSIONS

- Maternal Age
- Height, Pre-Pregnancy Weight
- Previous VBAC
- Arrest disorder indication for prior cesarean?
- Race of Patient
RACE & VAGINAL BIRTH AFTER C-SECTION (VBAC) CALCULATOR

2017 - Vyas et. al. challenge the use of race in VBAC calculator, arguing that it exacerbates disparities by discouraging vaginal birth.

2021 - calculator updated to remove race, substitute prior treatment for chronic hypertension.

VBAC Calculator assigns lower likelihood of success with VBAC to African-American and Hispanic women.
RACE-BASED STATISTICAL GENERALIZATIONS & STEREOTYPING: A MIS-FRAMED TRADEOFF?

Using statistical data to generate predictions about individuals, especially relying on categories such as “race”, in hopes of improving clinical outcomes.

Harms of automated “stereotyping” that diminish clinical outcomes & may compound injustice.
STEREOTYPES, RISK, AND PERSONAL VALUES
PROBABILISTIC CLASSIFIERS

Data (e.g. lung x-ray)

Probability that it falls into a category (e.g. 51% likely to be cancerous)
• Probabilistic Classifier produces a **probability for each possibility**

• (e.g. 51% likely to be cancerous, 25% likely to be benign tumor ... )

• Diagnostic AI then applies **thresholds** in order to deliver recommendation

**THRESHOLD APPROACH**

- Below test threshold (< 15% likely)
- More testing required
- Treatment threshold (> 85% likely)
HOW & WHEN SHOULD AUTOMATED THRESHOLDS BE SET?
### FALSE POSITIVES AND FALSE NEGATIVES

<table>
<thead>
<tr>
<th>Event $\hat{y}$</th>
<th>Condition $y = 1$</th>
<th>Condition $y = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{y} = 1$</td>
<td>True positive</td>
<td>False positive</td>
</tr>
<tr>
<td>$\hat{y} = 0$</td>
<td>False Positive</td>
<td>False Negative</td>
</tr>
</tbody>
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This table is sometimes called a “confusion matrix”
## FALSE POSITIVES AND FALSE NEGATIVES

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= CAT! (True positive)
## FALSE POSITIVES AND FALSE NEGATIVES

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$\text{= CAT! (False Positive)}$
Jeffrey (1956): Scientists are not in the business of accepting or rejecting hypotheses; rather, they should assign probabilities or degrees of belief to them.

Steel (2015): Decisions about whether to accept or reject a scientific hypothesis can have implications for practical action.

When this happens, acceptance decisions should depend in part on non-epistemic value judgments about costs of errors (Johnson 2020).
THRESHOLD SETTING DEPENDS ON VALUES

Consequences of False Positive

Consequences of False Negatives
THRESHOLD SETTING HAS EPISTEMIC COSTS

Setting a decision threshold within a “black-box” medical AI system is sometimes preferred if it is seen as simpler for the clinician or as a shield against lawsuits.

However, automatic threshold-setting:

- Leaves information on the table, degrading quality of token decision instances
- Makes it harder for junior clinicians to develop clinical judgment and practice placing *appropriate* trust in the device
THRESHOLD SETTING HAS ETHICAL COSTS

Automatic threshold-setting also has ethical costs.

In clinical settings, there can be no “one-size-fits-all” decision threshold.

For patient autonomy, it is appropriate for the decision threshold to take values and attitudes towards risk of a particular patient into account.
BUILDING A PERSONAL RISK-VALUE PROFILE

For a given condition, what is the patient’s:

• Valuing of true positive
• Disvalue of false positive
• Valuing of true negative
• Disvaluing of false negative

• Attitude towards overdiagnosis and misdiagnosis
• Attitude towards overtreatment vs. undertreatment
• Expected expected value of additional years of life of varying quality levels.
Another way to discover the patient’s risk-value profile is to ask them to engage in hypothetical “gambles” such as:

“I would rather risk surgical complications to treat a benign tumor than risk missing a cancerous tumor” (Buchak 2013).
MAKING DECISIONS ABOUT THE FUTURE

Simple decision theory says:

\[ P = \text{Probability of an outcome occurring} \]

\[ V = \text{Value/utility of that outcome} \]

\[ P \times V = \text{Expected Value} \]
Simple decision theory says:

\[ P = \text{Probability of an outcome occurring} \]
\[ V = \text{Value/utility of that outcome} \]
\[ P \times V = \text{Expected Value} \]

Likelihood of finding ice cream in my freezer = 0.99
Value of freezer ice cream = 3

Value of ice cream from truck = 9
Likelihood of ice cream truck driving by = 0.3

Ice cream truck search = 2.70
Freezer ice cream search = 2.97
Ice Cream Van Search = 2.70
Freezer Ice Cream = 2.97
Alas ....
Adding Risk

Now let’s model risk of outcomes separately from their probability or their value. The combined score is the “risk weighted expected utility.”

How do you value the risk of:

• High chance of acceptable outcome vs.
• Low chance of great outcome vs.
• Low chance of devastatingly bad outcome
Value of becoming a jazz musician = 9
Probability of success = 0.3
Expected value = 3.6
Value of becoming a jazz musician = 9
Probability of success = .3
Expected value = 3.6

Value of being a band teacher = 3
Probability of success = .9
Expected value = 3.6

Expected values are the same
Value of becoming a jazz musician = 9
Probability of success = .3
Expected value = 3.6

Value of being a band teacher = 3
Probability of success = .9
Expected value = 3.6

*Expected values are the same – risks tolerances are different*
Buchak (2013) argues that it is rational to make decisions based on “risk-weighted expected utility” – to take into account our tolerances for risk in addition to our values and preferences.

$r(p)$ measures the importance of the top $p$-portion of outcomes.
CLINICAL DECISION-MAKERS SHOULD BE PROVIDED EITHER WITH PROBABILISTIC OUTPUTS OR ELSE WITH A RECOMMENDATION THAT TAKES BOTH THE PROBABILITIES AND THE PATIENT’S VALUES AND TOLERANCE FOR RISK INTO ACCOUNT.
CASE STUDY 1: BREAST CANCER SCREENING
Patients with unresponsive wakefulness syndrome (formerly known as the vegetative state) are in fact able to modulate their brain activity in response to commands (Kondziella et al. 2016; Edlow et al. 2017).

“keep opening and closing your right hand” will sometimes elicit different brain activity from the command “stop opening and closing your right hand”, even though the patient’s right hand does not move. This is called “cognitive-motor dissociation” (CMD) (Schiff 2015).
Motor Command Protocol and Data Processing, from Claassen et al. (2019)
Temporal Pattern in Healthy Volunteers and in Patients with and Patients without Cognitive–Motor Dissociation.
HOW TO INCORPORATE PATIENT VALUES & RISK PROFILES

1. RAW SCORE
Output of the AI or medical device is the raw probability score.
Clinician uses verbal or written summary of patients’ values and risk profile to arrive at recommendation.

2. INCORPORATE INTO RECOMMENDATION
In addition to probability, AI or medical device also displays “second opinion” recommendation that incorporates risk-value profile.
STEREOTYPING ABOUT VALUES: STATISTICAL GENERALIZATIONS IN CULTURAL ATTITUDES
Cross-Cultural Issues in the Disclosure of Cancer

Jill L. Mitchell MA


✉ Jill L. Mitchell 108 Mattek Ave., DeKalb, IL 60115.

Abstract

PURPOSE: To increase awareness of cultural differences in the disclosure of a cancer diagnosis or prognosis, the author reviews several surveys of patients and physicians from around the world.

OVERVIEW: The Western medical community is increasingly emphasizing full truthful disclosure of cancer diagnoses or prognoses and respect for autonomy as necessary prerequisites to ethical practice. However, surveys of European, Japanese, Native American, and various ethnic American (including Korean, Chinese, Mexican, Hispanic, African, and European American) cancer patients and physicians reveal that many cultures consider complete and accurate disclosure potentially threatening to the patient’s well-being and self-esteem. Further, physicians’ attempts to disclose full information are regularly met with patient refusals, as patients resist facing information they view as at odds with familial and cultural norms.
A Systematic Review of Cultural Preferences for Receiving Medical "Bad News" in the United States

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Received 3 July 2014; revised 20 August 2014; accepted 4 September 2014

ABSTRACT

According to the dominant models of medical ethics in the United States and n
countries, physician disclosure of information such as diagnosis, treatm
is considered an essential precondition for patient inform
of autonomy... Surveys of European, A
American (including Korean, and European American) cancer patients
many cultures consider complete and accurate
Preferes for Disclosure of Information about Serious Illness among Older Korean American Immigrants in New York City

Cathy S. Berkman and Eunjung Ko

Published Online: 29 Mar 2009 | https://doi.org/10.1089/jpm.2008.0236

Abstract

Background: The majority of persons of Western European background want to know their diagnosis and prognosis of serious illness, but minimal information is preferred by some ethnic groups, including Asians. Little is known about disclosure preferences of Korean Americans, the fourth largest East Asian immigrant group in the United States.

Objective: The objective was to describe disclosure preferences about serious illness of Korean Americans in New York City and characteristics associated with disclosure preferences.

ABSTRACT

According to the dominant models of health beliefs, physician disclosure of information (whether positive or negative) is considered an essential aspect of medical care. Generally, Western cultures consider complete and accurate information about a serious illness to be of paramount importance. This study examines the disclosure preferences of Korean American patients receiving care at a New York City facility and compares their preferences with those of non-Hispanic White American patients.
Let's Ask the Patient!

STATISTICAL GENERALIZATIONS BASED ON CULTURAL PREFERENCES

Let's Ask the Patient!

American Illness among Older Korean Immigrants in New York City

Cross-cultural disclosure of cancer

Serious illness

Health care preferences in older European Americans

Cultural preferences in health care

Ethnicity and health care preferences

Cultural beliefs and health care decisions

Health care preferences and cultural beliefs

Cultural influences on health care decisions

Health care preferences and cultural influences

Cultural factors in health care decisions

Cultural considerations in health care decisions

Cultural aspects of health care decisions

Cultural roles in health care decisions

Cultural impacts on health care decisions

Cultural implications for health care decisions

Cultural considerations for health care decisions

Cultural effects on health care decisions

Cultural perspectives on health care decisions

Cultural influence on health care decisions

Cultural relevance for health care decisions

Cultural context in health care decisions

Cultural significance in health care decisions

Cultural contribution to health care decisions

Cultural aspects of health care

Cultural influences on health care

Cultural perspectives on health care

Cultural impact on health care

Cultural role in health care

Cultural relevance for health care

Cultural context for health care

Cultural significance in health care

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Cultural contribution to health

Cultural aspects of health problems

Cultural influences on health problems

Cultural perspectives on health problems

Cultural impact on health problems

Cultural role in health problems

Cultural relevance for health problems

Cultural context for health problems

Cultural significance in health problems

Cultural contribution to health problems

Cultural aspects of health disparities

Cultural influences on health disparities

Cultural perspectives on health disparities

Cultural impact on health disparities

Cultural role in health disparities

Cultural relevance for health disparities

Cultural context for health disparities

Cultural significance in health disparities

Cultural contribution to health disparities

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Cultural impact on health care disparities

Cultural role in health care disparities

Cultural relevance for health care disparities

Cultural context for health care disparities

Cultural significance in health care disparities

Cultural contribution to health care disparities

Cultural aspects of health care utilization

Cultural influences on health care utilization

Cultural perspectives on health care utilization

Cultural impact on health care utilization

Cultural role in health care utilization

Cultural relevance for health care utilization

Cultural context for health care utilization

Cultural significance in health care utilization

Cultural contribution to health care utilization

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THANK YOU!

REFERENCES:
• BUCHAK, WEIGHING THE RISKS OF CLIMATE CHANGE
• BIRCH ET. AL., CLINICAL DECISIONS USING AI MUST RESPECT PATIENT VALUES

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