

Evaluating the Accuracy of Data Collection on Mobile Phones: A Study of Forms, SMS, and Voice

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ICTD 2009

Mobile Data Collection is in Style

- **Especially in the developing world**

- Mobile banking
- Microfinance
- Healthcare
- Environmental monitoring



MOSNEWS.COM

Russia to introduce mobile phone voting in 2011

9 Apr, 03:38 PM

At the 2011 parliamentary elections, Russians will be able to cast their votes via their mobile phones, the Central Elections Commission has said.

- **Benefits:**

- Faster
- Cheaper
- More accurate

No prior study of entry accuracy
(on low-cost phones in developing world)

Data Collection on Mobile Phones

OpenROSA

FrontlineSMS Forms [[Banks](#)]

Nokia Data Gathering [[Nokia](#)]

RapidSMS [[UNICEF](#)]

MobileResearcher [[Populi.net](#)]

Cell-Life in South Africa [[Fynn](#)]

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Data Collection on PDAs

SATELLIFE

EpiHandy

EpiSurveyor [[Datadyne](#)]

Infant health in Tanzania [[Shrima et al.](#)]

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Respiratory health in Kenya [[Diero et al.](#)]

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Published Error Rates

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Tobacco survey in India [\[Gupta\]](#)

Ca:sh in India [\[Anantramanan et al.\]](#)

Published Error Rates

None?

CAM in India [\[Parikh et al.\]](#)

Published Error Rates

Malaria monitoring in Gambia [\[Forster et al.\]](#)

Clinical study in Gabon [\[Missinou et al.\]](#)

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Our Study

- Compared three interfaces for health data collection

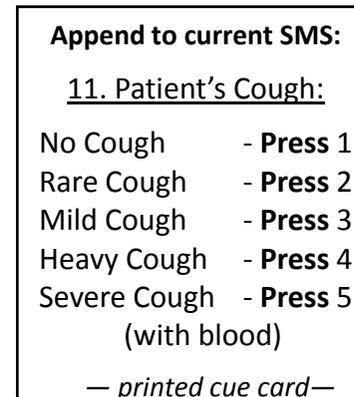
13 literate health workers & hospital staff, Gujarat, India

Electronic Forms



Error rate: 4.2%

SMS



4.5%

Live Operator



0.45%

Result caused partners to switch from forms to operator

- **Recommendations:**

1. Caution needed in deploying critical apps w/ non-expert users
2. A live operator can be accurate and cost-effective solution

Context: Rural Tuberculosis Treatment

- **With local partners, working to improve tuberculosis treatment in rural Bihar, India**



THE PRAJNOPAYA FOUNDATION



INNOVATORS IN HEALTH



- **Strategy: monitor patient symptoms remotely**



Health worker
uploads symptoms

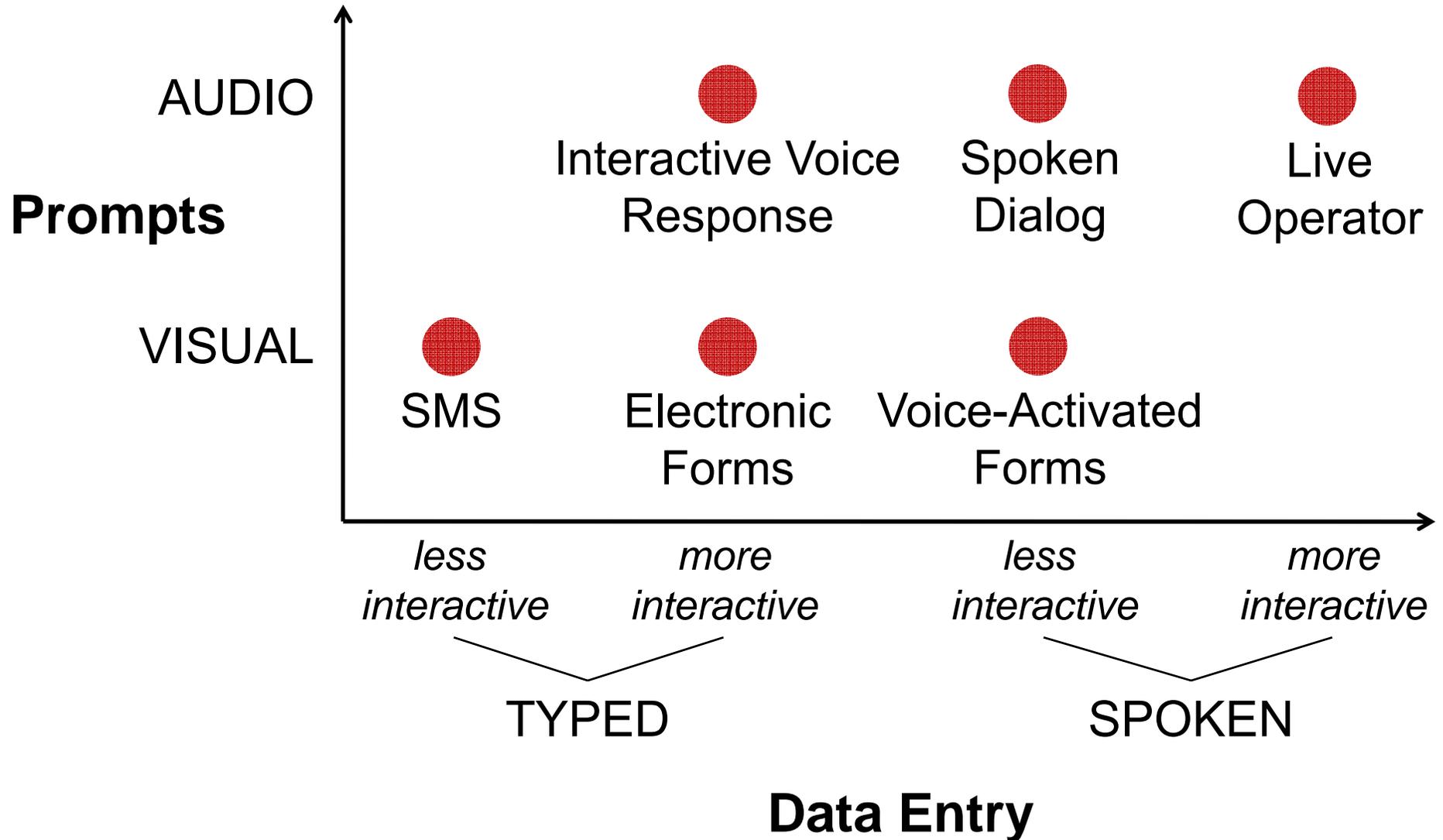
Physician reviews,
advises, schedules visits



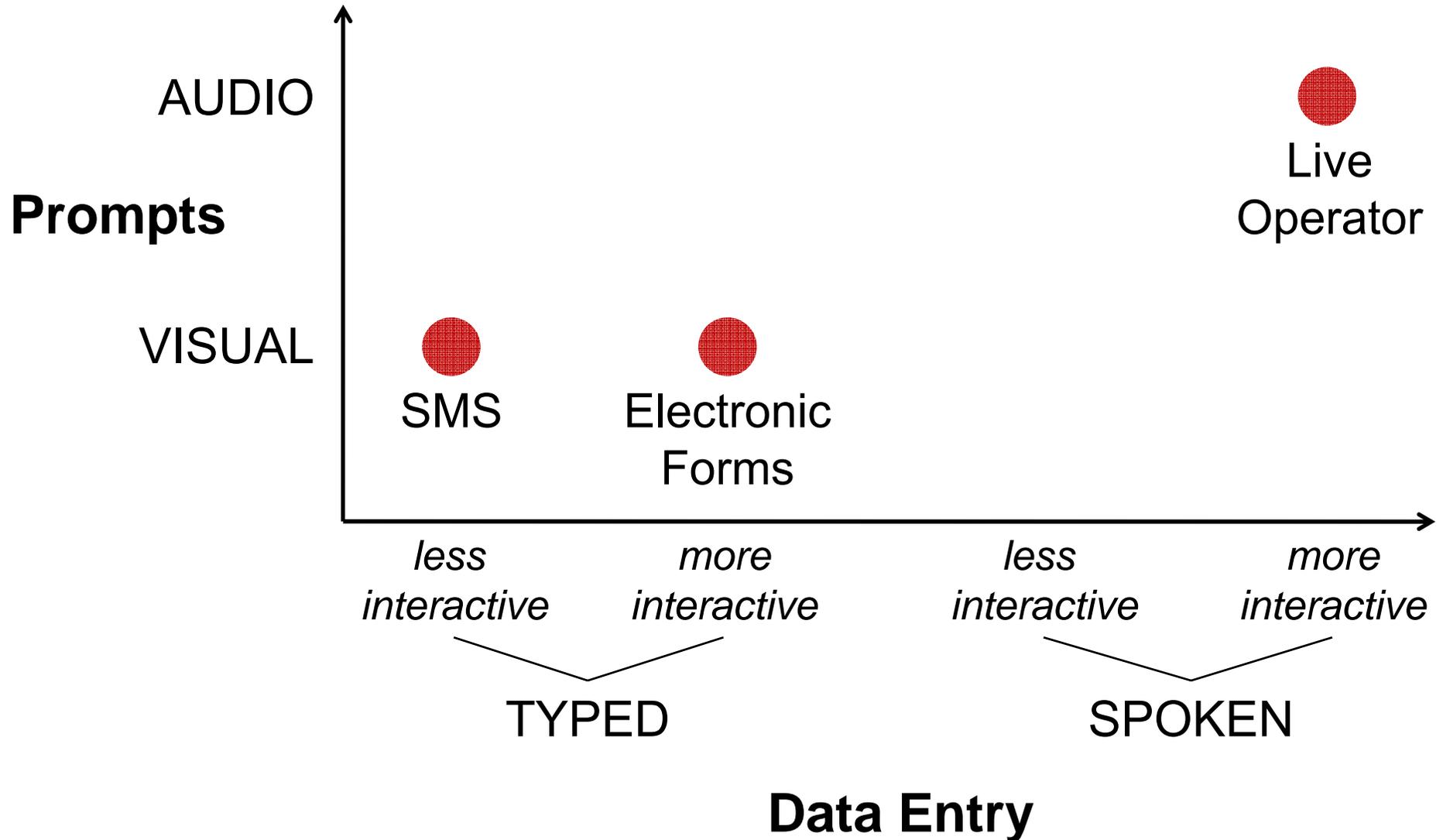
- **Data uploaded: 11 questions, every 2 weeks**

- Patient ID
- Temperature
- Weight
- Cough (multiple choice)
- Symptoms (yes / no)

Design Space: Data Collection on Low-End Phones



Design Space: Data Collection on Low-End Phones



1. SMS Interface

- **Pro:**
 - + Potentially cheapest
- **Con:**
 - Easiest to fake visits
 - Least reliable

⋮

11. Enter the Patient's Cough

No Cough	- Press 1
Rare Cough	- Press 2
Mild Cough	- Press 3
Heavy Cough	- Press 4
Severe Cough (with blood)	- Press 5

⋮

21. Check Yourself

Your finished message should be formatted similarly to the following:
10 372 62 68 4 1030007

2. Electronic Forms Interface

- **Pro:**
 - + Arguably more user friendly than SMS
- **Con:**
 - Expensive handset



3. Live Operator Interface

- **Pro:**
 - + Most flexible Q&A
 - + No literacy required
 - + Hard to fake visits
- **Con:**
 - Cost of operator
 - Potentially slower



Study Participants

- 13 health workers and hospital staff (Gujarat, India)

	Age (Median)	Education	Cell Phone Experience
Health workers (6)	23	10 th – 12 th	Had used phone
Hospital staff (7)	30	12 th – D. Pharm.	Owned phone

- **Within-subjects design**
- **Training standard:
two error-free reports
on each interface**
 - Health workers:
big groups, 6-8 hours
 - Hospital staff:
small groups, 1-2 hours



Results

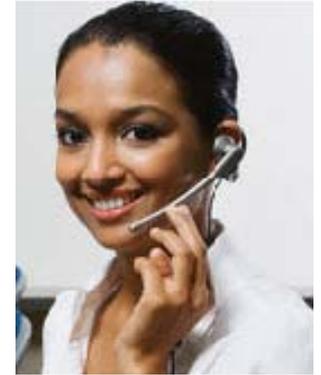


Append to current SMS:

11. Patient's Cough:

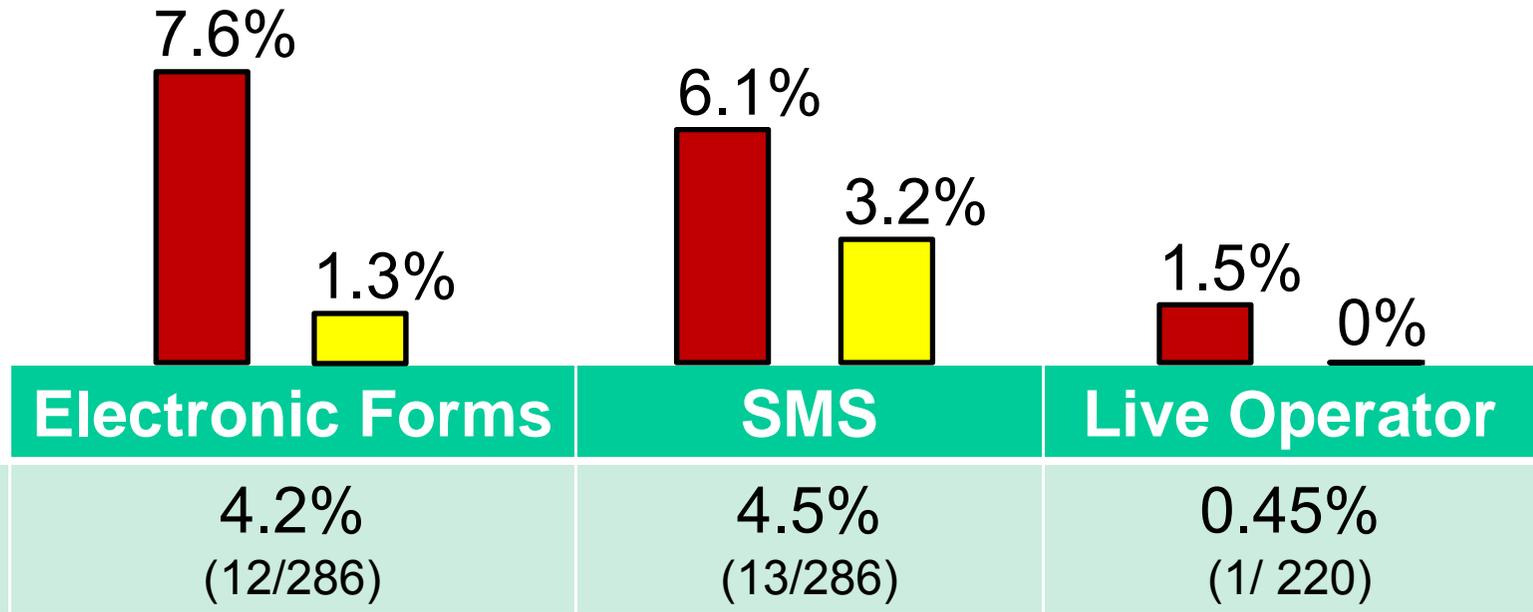
- No Cough - Press 1
- Rare Cough - Press 2
- Mild Cough - Press 3
- Heavy Cough - Press 4
- Severe Cough - Press 5
(with blood)

— printed cue card—

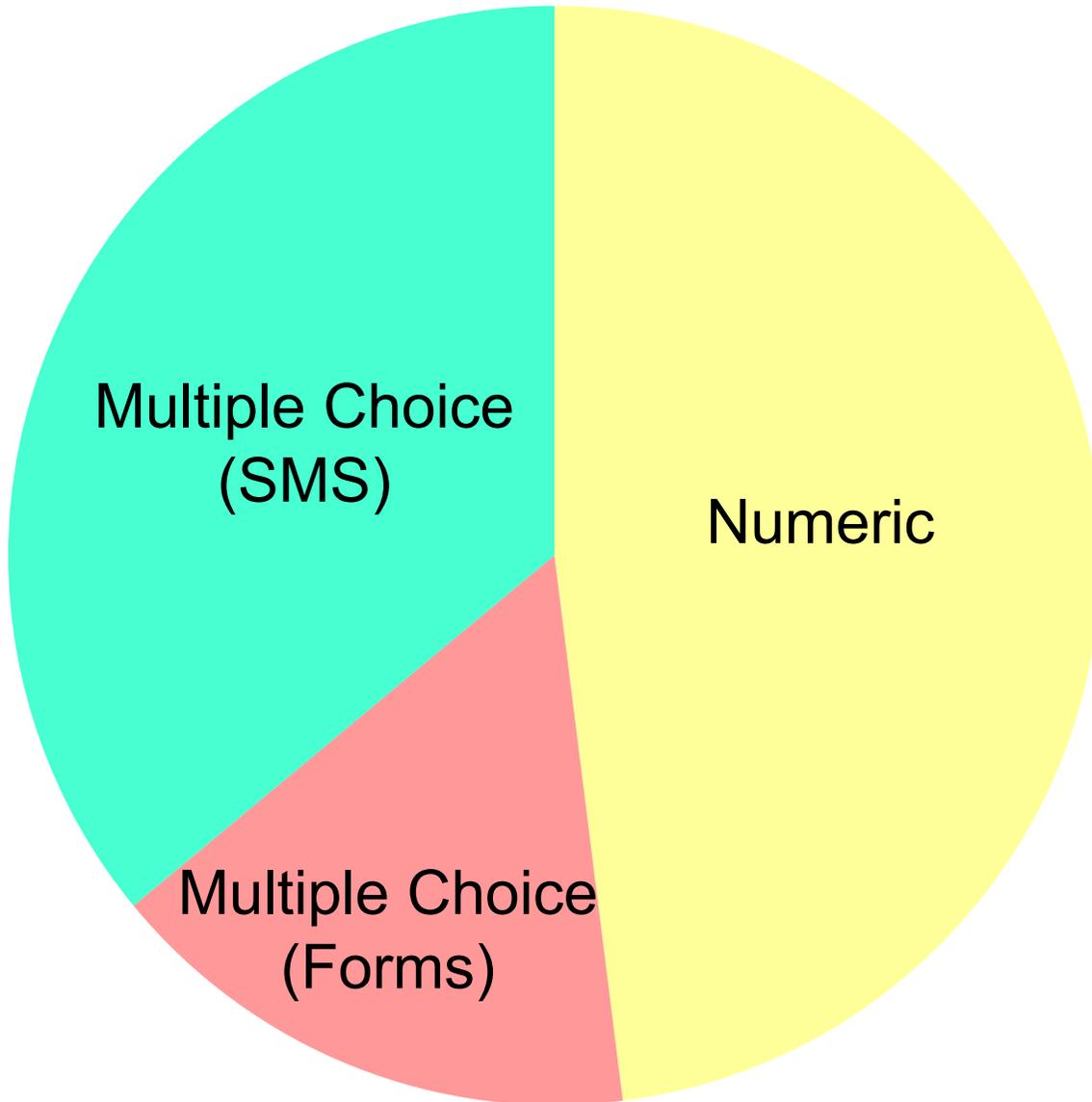


	Electronic Forms	SMS	Live Operator
Error rate (errors / entries)	4.2% (12/286)	4.5% (13/286)	0.45% (1/ 220)

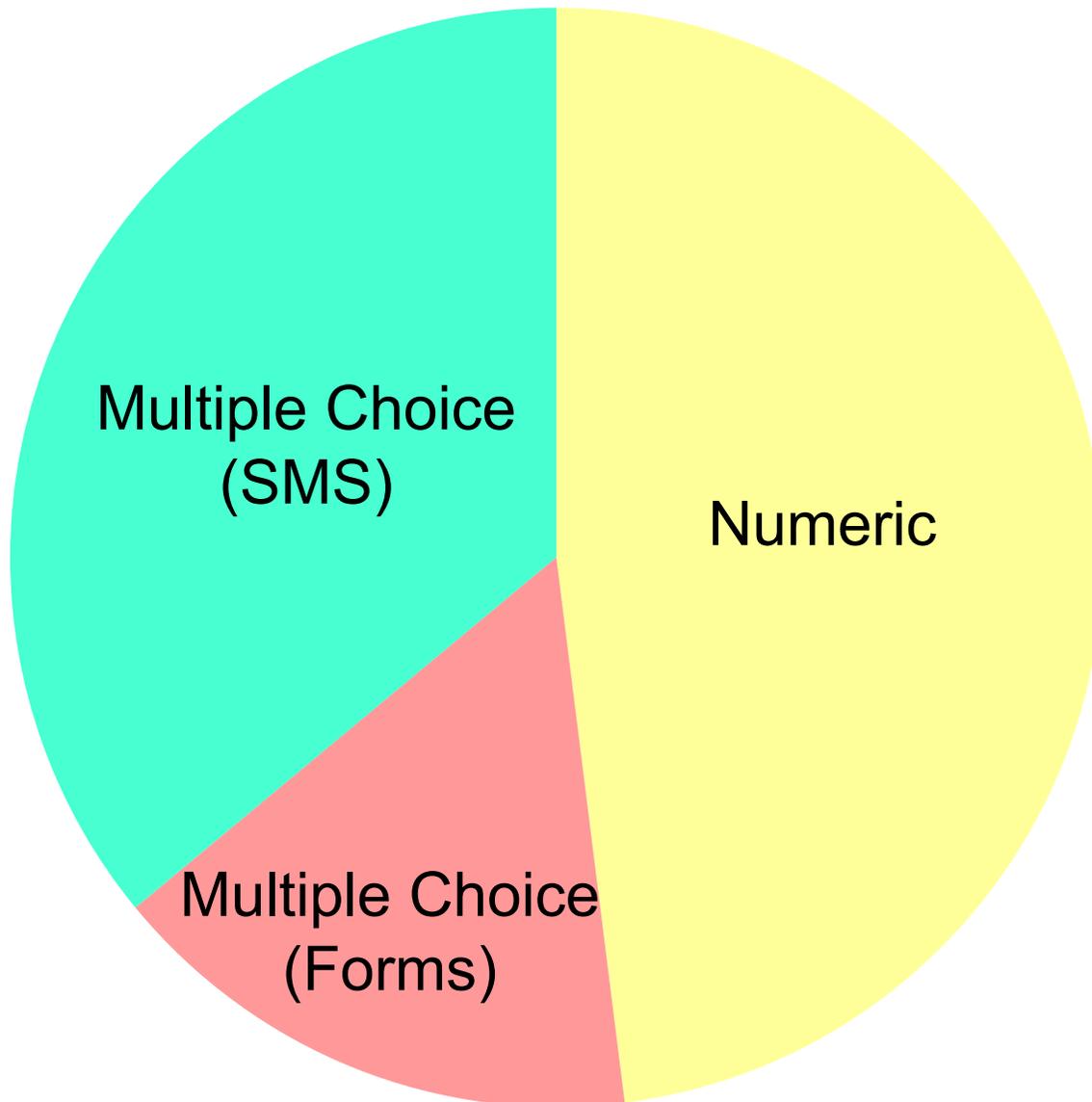
Results



Sources of Error



Sources of Error

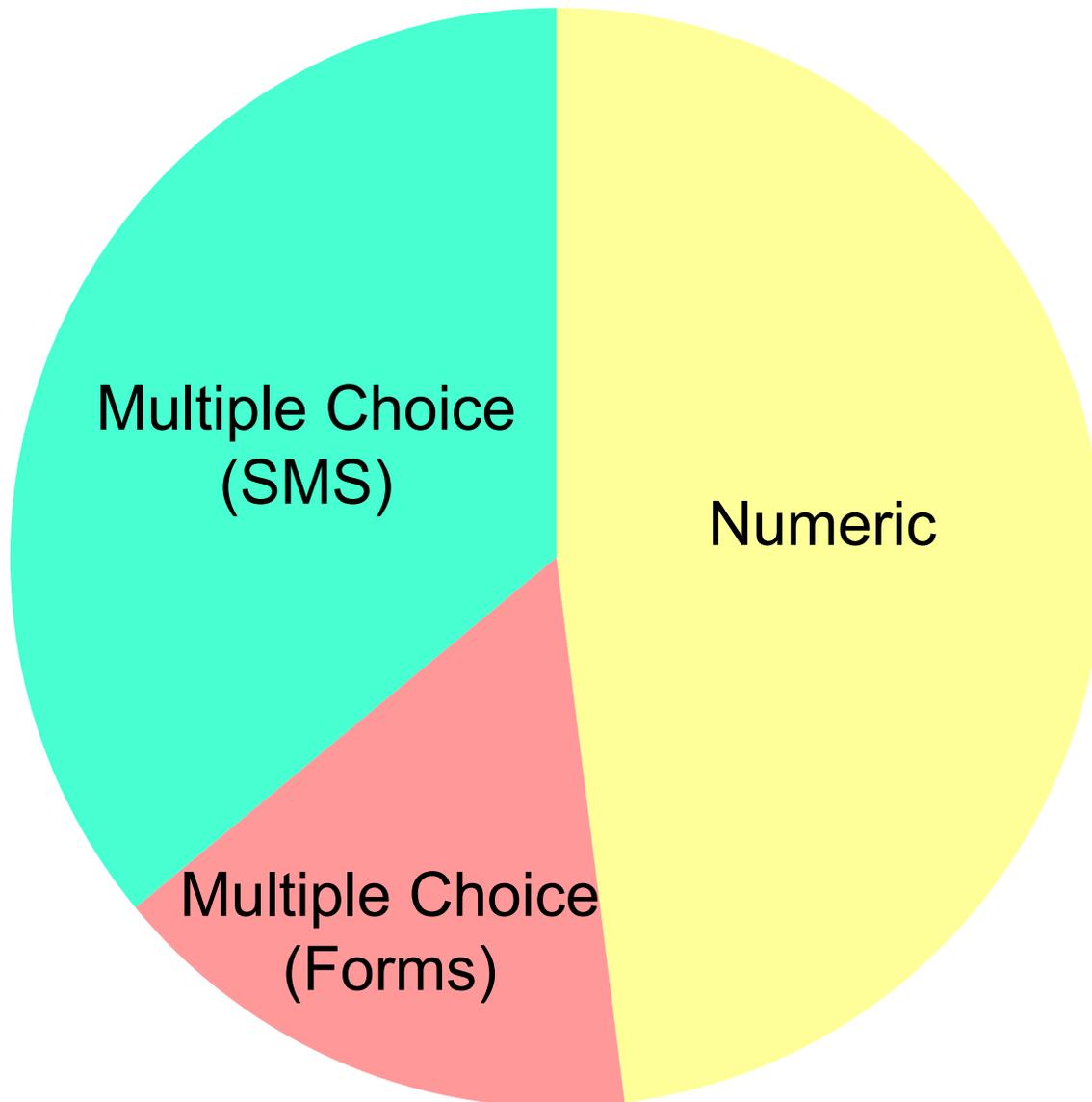


Usability Barriers

- small keys
- correcting mistakes
- decimal point

Correct	Incorrect
54	45
62	826
62	<i>empty</i>
68	67
68	93
69	59
98.5	98
98.7	98.687
100.2	100.0
100.3	103
“1003”	103
100.8	108

Sources of Error

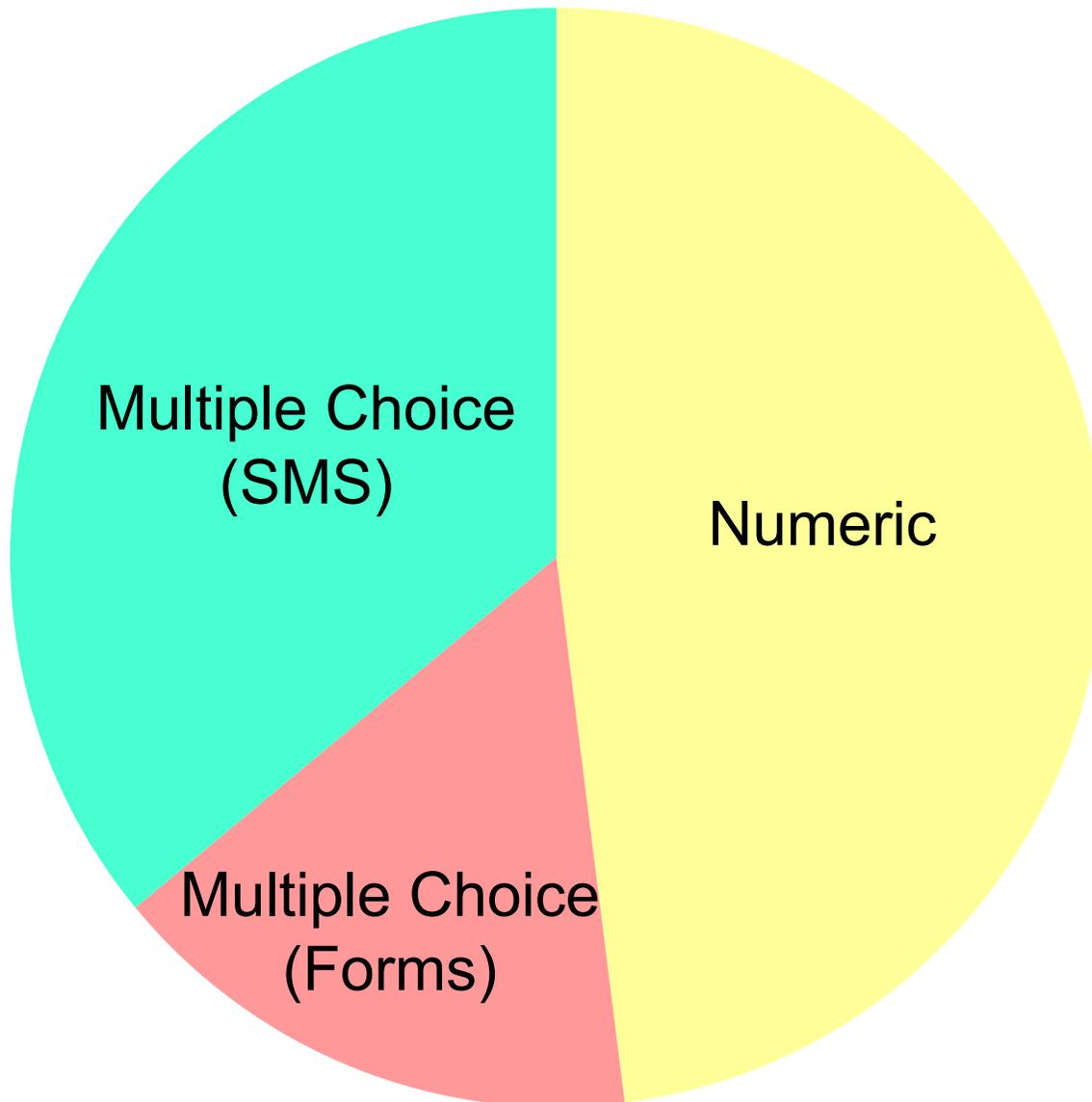


Usability Barriers

- small keys
- correcting mistakes
- decimal point
- scrolling / selection

Correct	Incorrect
Mild	None
Heavy	Mild
Yes	No
No	Yes

Sources of Error



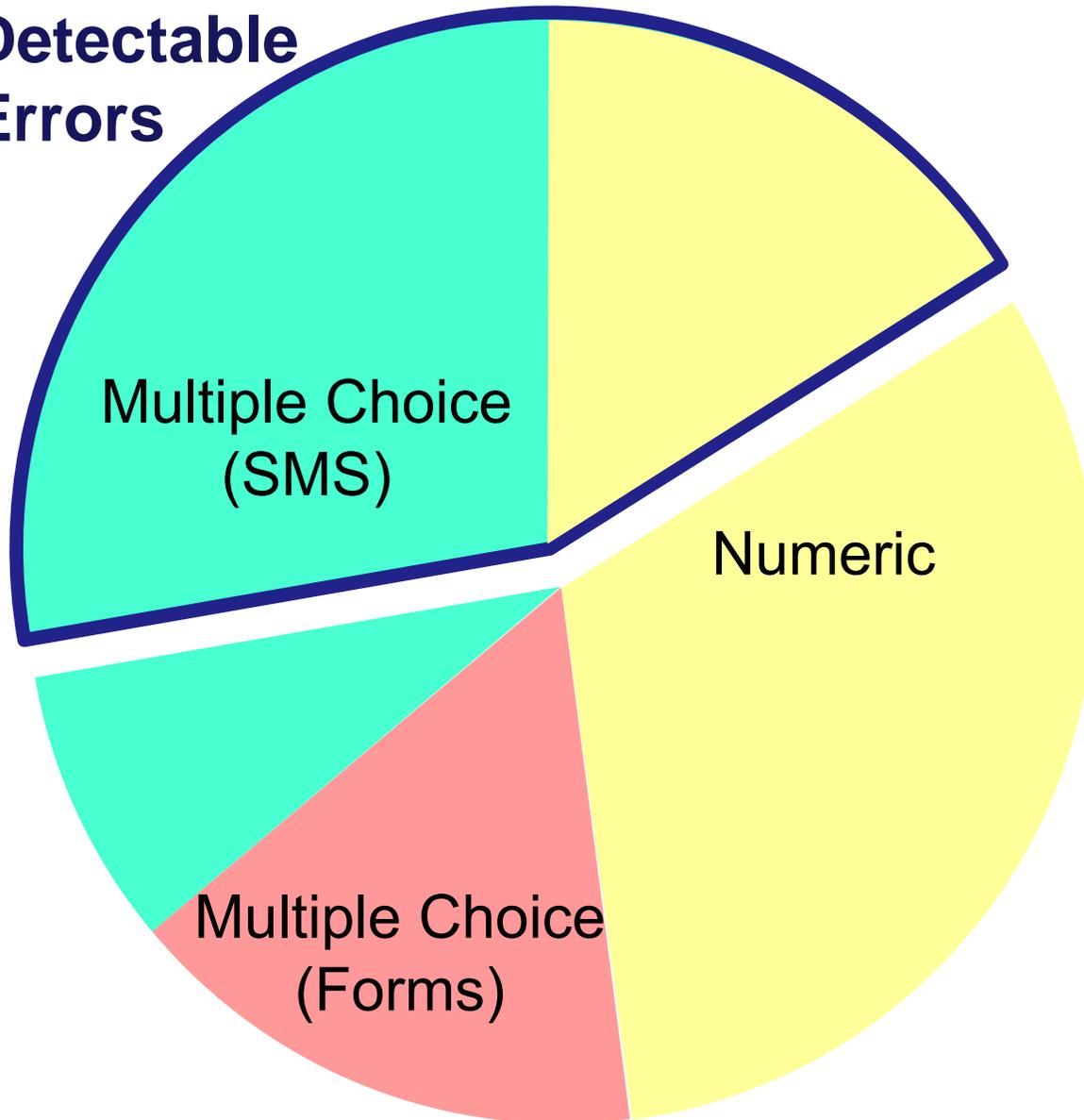
Usability Barriers

- small keys
- correcting mistakes
- decimal point
- scrolling / selection
- SMS encoding

Correct	Incorrect
"1" (none)	"0" (disallowed)
"1" (none)	"0" (disallowed)
"1" (none)	"0" (disallowed)
"3" (mild)	"0" (disallowed)
"5" (severe)	<i>empty</i>
"6" (A. Khanna)	"5" (A. Kumar)
"7" (A. Kapoor)	"1" (A. Khan)
"6"	"2"
"0000007"	"000007"

Sources of Error

**Detectable
Errors**



Usability Barriers

- small keys
- correcting mistakes
- decimal point
- scrolling / selection
- SMS encoding

Cost Comparison

	SMS	Forms	Live Operator
Cost per interview	C_s	C_s	$(C_v + C_o) T$

Program variables

T time spent per interview

Cost variables

C_s cost of an SMS

C_v cost of a voice minute

C_o cost of an operator minute

Cost Comparison

	SMS	Forms	Live Operator
Cost per interview	\$0.03	\$0.03	\$0.06 T

Program variables

T time spent per interview

Cost variables in Bihar, India

\$0.03 cost of an SMS

\$0.02 cost of a voice minute

\$0.04 cost of an operator minute

Cost Comparison

	SMS	Forms	Live Operator
Cost per interview	\$0.03	\$0.03	\$0.06 T

Break-even call: 30 seconds

Program variables

T time spent per interview

Cost variables in Bihar, India

\$0.03 cost of an SMS

\$0.02 cost of a voice minute

\$0.04 cost of an operator minute

Cost Comparison (TB Program)

	SMS	Forms	Live Operator
Cost per interview	\$0.03	\$0.03	\$0.15
Cost per phone	\$25	\$50	\$25
Total cost	\$29	\$54	\$43

SMS < Live Operator < Forms

Program variables

2.5 min time spent per interview
120 number of interviews
 for duration of program

Cost variables in Bihar, India

\$0.03 cost of an SMS
\$0.02 cost of a voice minute
\$0.04 cost of an operator minute

Cost Comparison (Microfinance)

	SMS	Forms	Live Operator
Cost per interview	\$0.03	\$0.03	\$0.60
Cost per phone	\$25	\$50	\$25
Total cost	\$40	\$65	\$325

Microfinance: Operator is 5x more expensive than Forms

Program variables

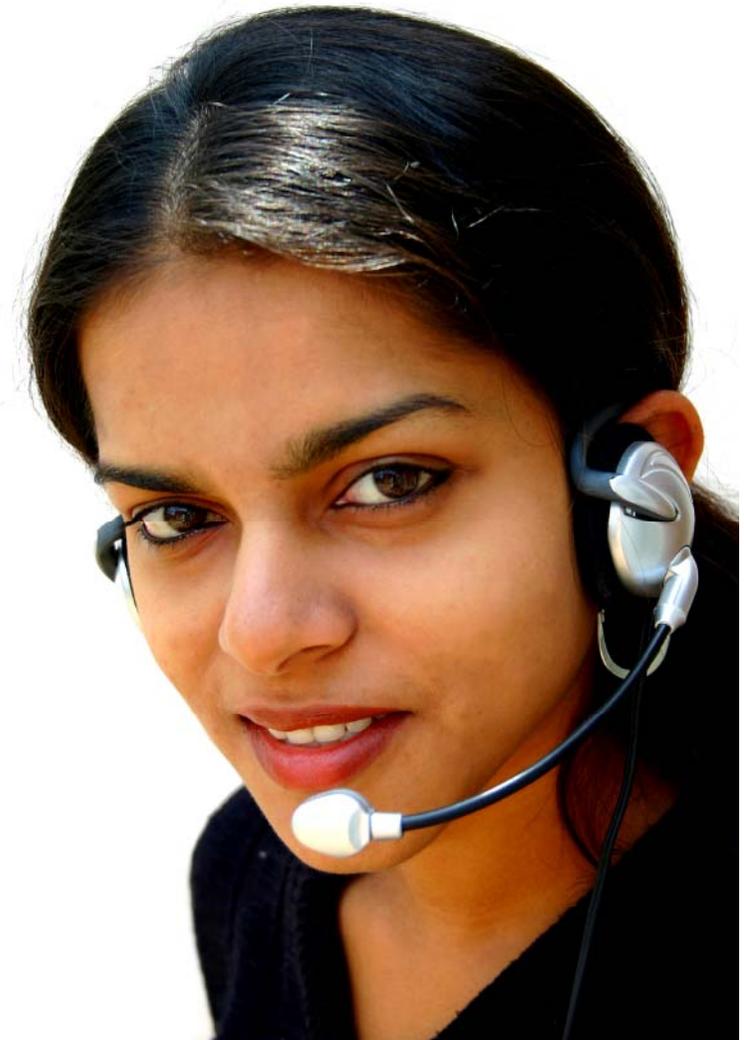
10 min time spent per interview
500 number of interviews
 for duration of program

Cost variables in Bihar, India

\$0.03 cost of an SMS
\$0.02 cost of a voice minute
\$0.04 cost of an operator minute

The Case for Live Operators

- **Our proposition:**
Operators are under-utilized for mobile data collection
- **Benefits:**
 - Lowest error rate
 - Less education and training needed
 - Most flexible interface
- **Challenges:**
 - Servicing multiple callers



Related Work

- **Personal digital assistants (PDAs) for mobile health**
 - 8+ hours training, educated workers: 0.1% - 1.7% error rates
[Forster et al., 1991] [Missinou et al., 2005] [Blaya & Fraser, 2006]
 - 2-3 minutes training, uneducated workers: 14% error rate
[Bernabe-Ortiz et al., 2008]
 - In developed world: mixed results vs. paper forms
[Lane et al., 2006]
- **Richer interfaces**
 - CAM: <1% error rates via camera phone [Parikh et al.]
 - Speech [Patel et al., 2009] [Sherwani et al. 2009] [Grover et al.] [...]
 - Interfaces for low-literate users [Medhi et al.]

Conclusions

- **Accuracy of mobile data collection demands attention**
 - We measured 5% error rates for those lacking experience
- **There exist cases where a live operator makes sense**
 - Error rates shrunk to 0.5%
 - Can be cost effective, esp. for short calls or infrequent visits
- **Our study has limitations**
 - Small sample size
 - Varied education, phone experience, training of participants
- **Future work**
 - Distinguish factors responsible for error rates
 - Compare to paper forms, Interactive Voice Response