



INNOVATIVE TECHNOLOGIES FOR DATA COLLECTION IN AGRI-NUTRITION RESEARCH

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OUTLINE

- Energy Count(s): Measuring energy expenditure in agricultural and rural livelihoods using accelerometer devices
- ICTs for women's time use and maternal and infant dietary practices
- Lunch break
- Group Activity
- Experiences from IMMANA Projects
- Reflections on use of the methods, further empirical applications

TECHNOLOGIES FOR DATA COLLECTION IN AGRI-NUTRITION RESEARCH

- Agri-nutrition policies need evidence to be effective
- Some dimensions are intrinsically difficult to capture by nature, e.g. time use, food intake, physical activity
- New technologies can support data collection, improving measurement and quality of data
- Technologies that are not developed for research purposes provide opportunities and challenges

PART 2
INTRODUCTION OF
METHODOLOGIES

INNOVATIVE METHODS FOR MEASURING PHYSICAL ACTIVITY



**WHY THE HUMAN ENERGY
COMPONENT IS IMPORTANT IN
NUTRITION RESEARCH**

**(AND MORE GENERALLY
IN AGRI-HEALTH ANALYSIS)**

OVERVIEW AND INTUITION

Giacomo Zanello

1

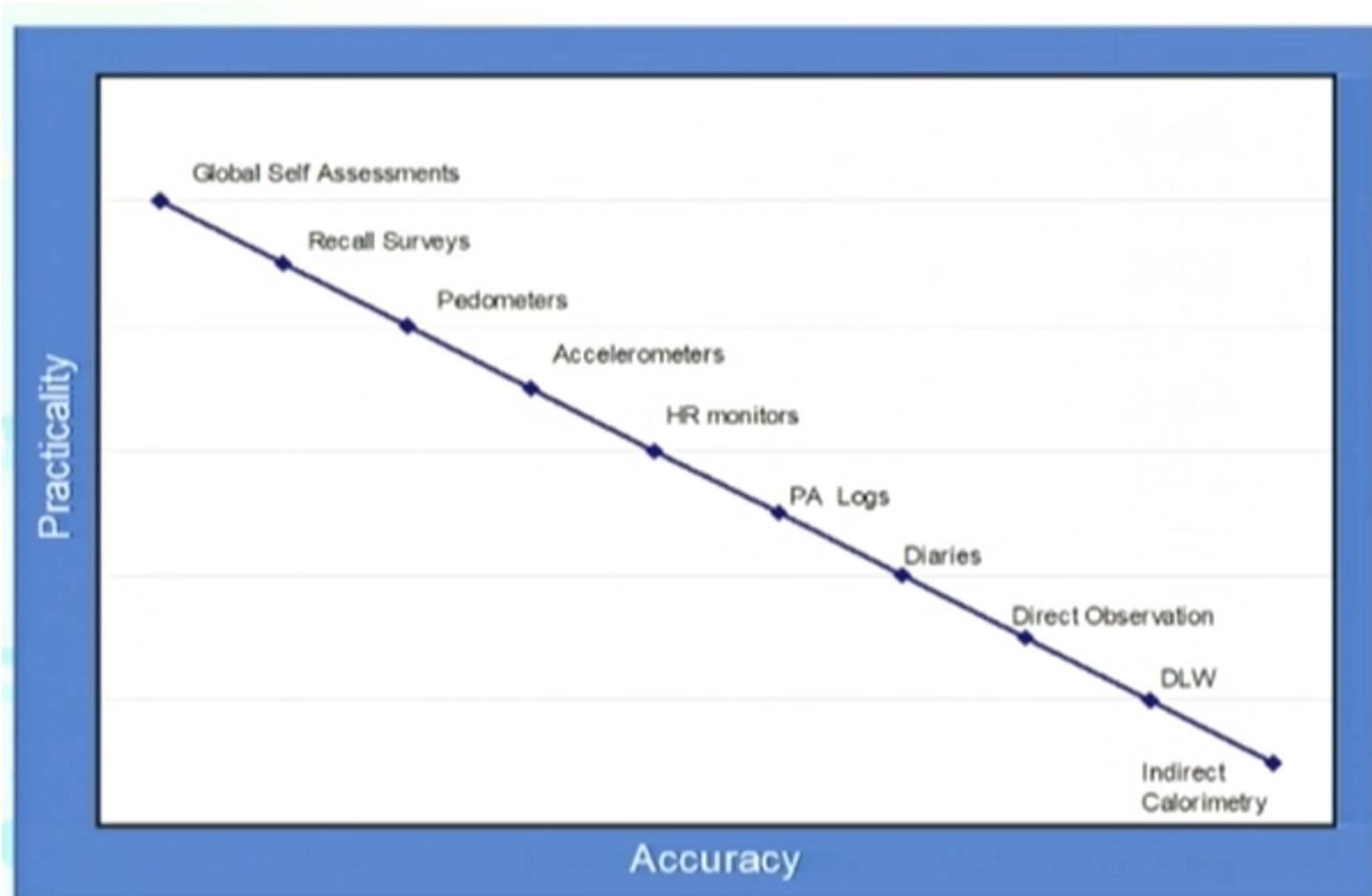
MOTIVATION

- In many developing countries, there appears to be a perplexing **disconnect** between agricultural productivity growth and expected improvements in nutrition status (Gillespie and Kadiyala, 2012)
- Most of the research on nutrition in low and middle income countries has predominantly focused on changes in diets while the **physical activity has been largely neglected** (Popkin, 2006; Zanello et al., 2018)
- Productivity-enhancing agricultural interventions impact the nutritional status via direct impacts on **energy intake** as well as **energy expenditure**

THE IDEA

- Develop a **methodological framework** in which energy expenditure data from accelerometry devices is integrated with complementary data sources
- The methods and approach can be used to facilitate a better understanding of:
 - i. The **link between agricultural development interventions and nutrition outcomes** for different members of rural households
 - ii. The **intra-household, gender differentiated labour allocation and energy expenditure patterns**
 - iii. The **prevalence, depth and severity of undernutrition** in rural areas in developing countries

HUMAN ENERGY MEASUREMENT TOOLS



Hitchhiker's guides:

Dollman et al. J Sci Med Sport. 2009 Sep;12(5):518-25

Hardy et al. J Sci Med Sport. 2013 Jan;16(1):28-35

WHAT ACCELEROMETERS ARE AND HOW THEY WORK

Nithya Gowdru

2

ACCELEROMETERS DEVICES

- Accelerometers devices are devices that measure proper acceleration across the three axes (x, y, z)
- Acceleration can then be converted in movement and energy expenditure
- It is based on physics: How much energy you need to move a body (you!) from A to B with the intensity of Q



HOW THE ACCELEROMETERS CAPTURE PHYSICAL ACTIVITY (BIT TECHNICAL!)

- Tiny structures in the device produce electrical signals proportional to the acceleration it detects (data are sampled 30 times per second)
- Filtered to eliminate signals unlikely to be caused by human movement (vibration, temperature changes, electrical interference, car accidents, etc.)
- Further processing occurs to clean the signal and make it easier to interpret. Signals are summed across a user-defined period (the “epoch” - typically 1-3 mins) and an output read to the flash memory

ACCELEROMETRY DEVICES

- Why ActiGraph GT3X+?
 - Non-intrusive and waterproof, and suitable for 24 hours continuous use in free living populations.
 - Rugged, no screen, no on/off switch. Little resale value
 - Adequate support and comprehensive software
 - Battery life of 30 days
- The reliability and validity of ActiGraph devices have been extensively assessed (Santos-Lozano et al., 2013; Sasaki et al., 2011) and these devices have been used in multiple studies involving free-living humans in various settings (Keino et al., 2014; Pawlowski et al., 2016)

WHICH DATA WE GET

- Minutes spent in different intensity categories
- Energy Expenditure
- Steps per day
- Inclinometer
- Light
- Pairing with heart rate monitor



ACTIGRAPH: HOW TO WEAR IT

- Worn on waist, over right hip, snug fit
- Over or under clothing
- Please note the USB port must be placed at the top



USING DEVICES ON THE FIELD: CHARGING AND INITIALIZATION

- The devices are always charged and initialized a day prior to the start of each round of data collection
- The device is initialized using respondent's biodata (age, sex, height, weight)
- In the initialization process, there is a calendar (time and date) of start time and end time.
- Identification of devices by attaching pins to the belts

ACCELEROMETERS IN LMICs

Radhika Cherukuri

3

COMPLIANCY

- Respondents understood clearly the nature and purpose of the survey
- Choice of visiting hours
- Choice of Enumerators: understanding the local environment; ability to communicate in the local language; friendliness, commitment/dedication
- A strict workflow, including checklists
- Adequate training
- Demonstration by wearing the device
- Incentives?

WHAT TO TELL PARTICIPANTS

- It records overall movement, much like a pedometer
- It is harmless – it runs on a battery, like your watch
- There is not an ‘on’ and ‘off’ switch
- It cannot tell what type of activity you are doing
- It cannot tell where you are, it is not a tracking device
- You do not need to be an ‘active’ person for the device to work
- “Movement meter” – it is just recording, not monitoring or measuring
- There is no screen to look at
- It is expensive for researchers, but has no street value

WHAT NOT TO TELL PARTICIPANTS

- “The accelerometer will tell us how much you exercise, walk, etc.” (we do not want to influence activities)
- “Make sure to move a lot while you are wearing the device!”
- “You have a large farm so we expect the accelerometer to show you will be walking a lot”
- “It is OK to remove the accelerometer when you are not doing much since we are mostly interested in physical activity”
- “The accelerometer can tell if you are sitting around cooking, working on the field, etc.”

COMMUNITY ENGAGEMENT AND FEEDBACK FROM PARTICIPANTS

- Community Engagement
 - Community entry through the ‘village sarpanch’
 - Selection and sensitization of respondents: device records only energy output
- Feedback (quotations from participants)
 - *“We went ahead with our normal daily activities while the project continues”*
 - *“Accelerometer devices created some curiosity from other fellow farmers”*
 - *“At the beginning we thought that wearing a device will distract and feel uncomfortable , but after few days we got used to it”*

FEEDBACK FROM THE PARTICIPANTS

- Some respondents initially thought the devices could have some adverse effects on them
- Some participants were concerned they were unable to see exactly what was recorded and only had to trust what they were told by the enumerators
- Few participants thought the devices were like some medical aid that could help them to work more on the farm
- Participants felt part of a meaningful research
- Even though intensive, they said the data collection process was flexible

PHOTOS FROM THE FIELD



PHOTOS FROM THE FIELD



PHOTOS FROM THE FIELD



PHOTOS FROM THE FIELD



DATA MANAGEMENT AND PRESENTING RESULTS

Fiorella Picchioni

4

ACCELEROMETRY DATA

- Accelerometry data alone is rather limited
- Greater insights when data is triangulated
- Importance of study design!

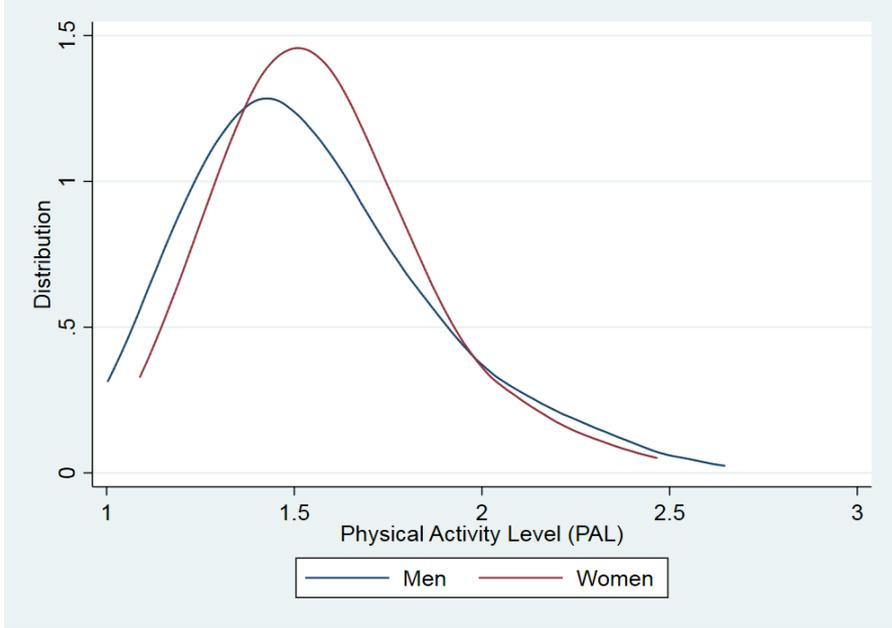
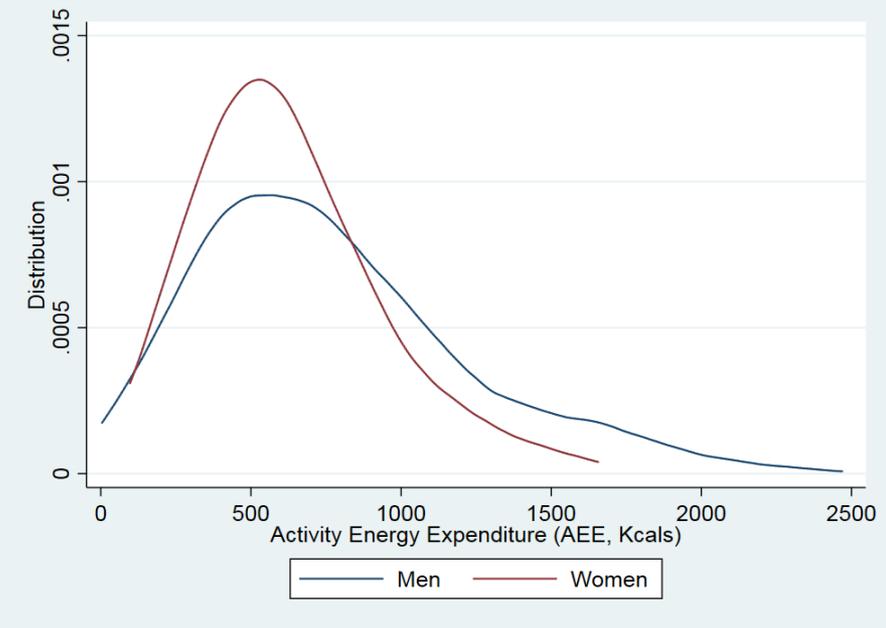
MULTIPLE SOURCES OF DATA - FILES

- Accelerometry data often is combined with other data, possibly collected with individual questionnaires
- Benefit of collecting data electronically
- Multiple dimensions of data: hourly data, daily, weekly, etc.
- Spend time developing a protocol for data management:
 - File names and identifier
 - Clear Stata do-files
 - Consistency across sources

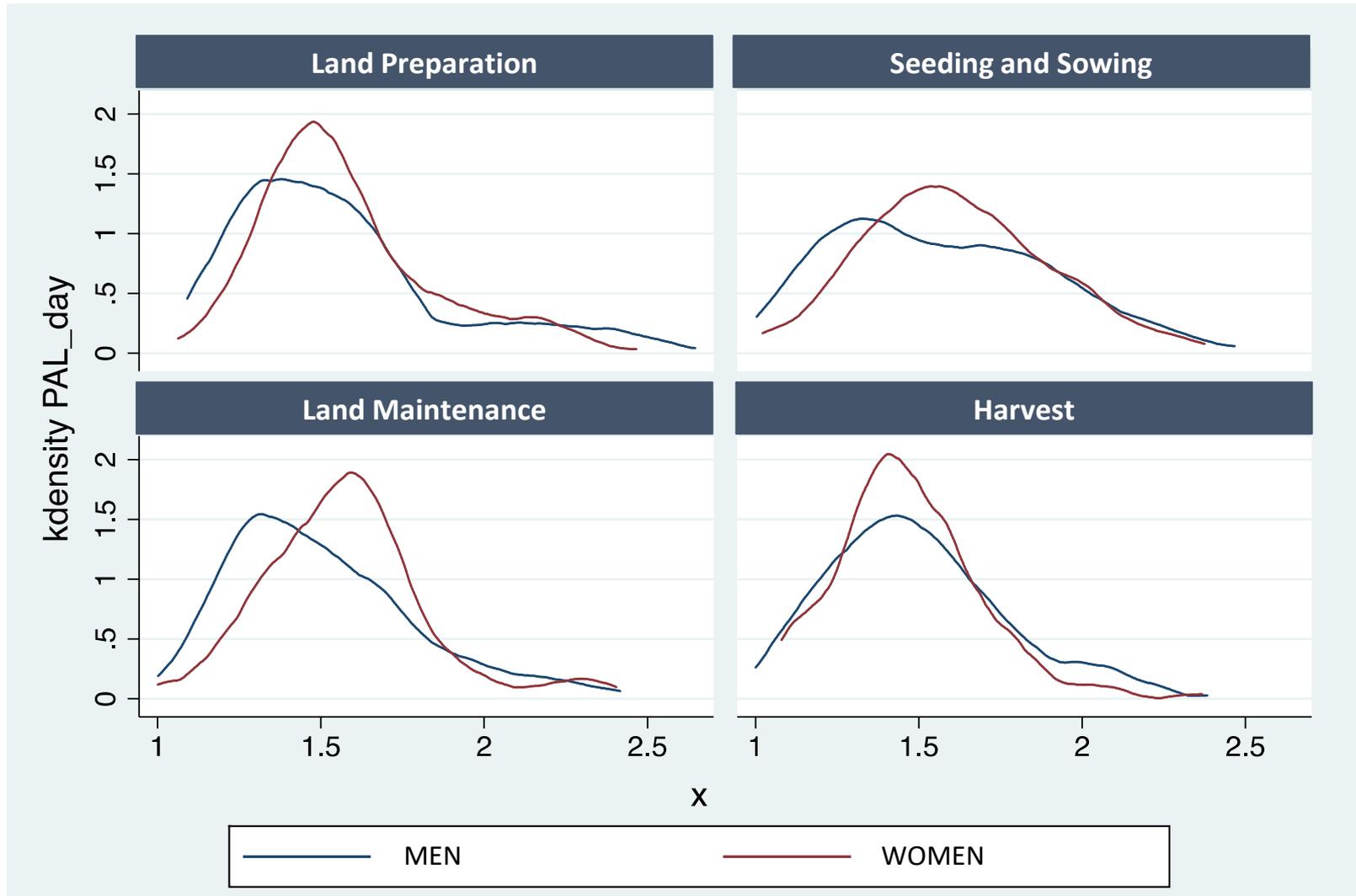
INDIVIDUAL CHARACTERISTICS

| Men (n = 20) | | Women (n = 20) | | Sample (n = 40) | | |
|---------------------|-----------|-----------------------|-----------|------------------------|-------------|-----------|
| Mean | SD | Mean | SD | Diff | Mean | SD |

DISTRIBUTION OF ACTIVITY ENERGY EXPENDITURE (KCAL) AND PAL BY GENDER



SEASONAL DISTRIBUTION OF PHYSICAL ACTIVITY LEVEL FOR WOMEN AND MEN



INNOVATIVE METHODS FOR MEASURING DIETARY DIVERSITY AND TIME USE

Time use and nutrition research

- Conventional methods for assessing time use and dietary practices:
 - **24 hour recall** (or longer) accuracy depends on: respondent's memory, interviewer skills, absence of respondent or social desirability bias
 - **Direct observation** is the 'gold standard': most accurate method. But has high respondent burden, high researcher time commitment, prone to reactivity and respondent bias
- Opportunities to use digital tools for electronic data capture
 - Computerised Interactive Voice Response Dairies (IVR) via mobile phones
 - Life-logging GPS-linked wearable cameras

Interactive voice response (IVR)



Previous applications & potential (IVR)

Experiences from high-income countries:

- IVR diaries have been shown to reduce under-reporting and recall limitations compared to conventional recall (Gemming et al., 2015; Lai et al., 2010)
- Facilitates more frequent data collection, lowers researcher workload, contributes to more accurate and detailed data due to shorter delay (Statland et al, 2011; Brandt et al, 2007; Palen et al, 2002)
- Method typically has less burden on respondent, as no intrusion from enumerator (Palen et al, 2002)

Potential for lower & mid-income rural contexts

- Voice telephony is and will remain highest penetration 2-way communications channel in LMICs
- Lower literacy requirements compared to SMS and USSD
- Low marginal costs, therefore potentially very scalable

Life-Logging Wearable Camera (LLWC)



Life-Logging Wearable Camera (LLWC)

- **Experiences from high-income countries**
 - More objective method of data collection, accurate record of timing & duration
 - Low respondent and interviewer burden
 - Has been shown to reduce underreporting of energy intake (Gemming et al. 2015, Pettitt et al. 2016)

Protocol for IVR

- Sensitize mothers/ older children or spouses about using the mobile phones
- Trial calls on sensitization day
- Give phone in pouch to reduce inconvenience during working
- Calls every 3-4 hours
- Each call: Questions on time use, child diet, mothers diet
- Data in combination with GPS/images for time use

Protocol of LLC

- Sensitize mothers/ older children or spouses about using the cameras
- Go through the dos and don't-Water, capturing clear images, worry about capturing personal information
- Trial usage on sensitization day
- Attach camera on mother as soon as she wakes up till 8.30 when team is leaving field or if mother wants to sleep before then
- Images transferred to a tablet and initial interpretation by enumerator
- Images are then used as recall aid for respondent
- combine images with IVR+ GPS data

LLWC: Device & data management

- Start of fieldwork (5 am)
 - Travel to respondents
 - Take photograph of respondent sheet and the respondent using LLWC
 - Attach camera to project t-shirt given respondent
 - Let respondent continue with daily activities as usual
- End of fieldwork (8.30 pm)
 - Collect camera & switch off
 - Check with respondent whether to delete any or all images
 - Record any other issues
- At hotel (~10 pm)
 - Download images to hard disk & delete those required (approx 1500 per camera per day)
 - Clear SD cards
 - Charge cameras
- Data security
 - Cameras are charged/kept in lockable 'safe-bag'
 - SD cards are cleared daily
 - Images are backed up to password-protected hard disk

Example of captured images

PART 3
GROUP ACTIVITY

GUIDELINES

- Design a research protocol for using either Accelerometry or Interactive Voice Response Diaries (phone) or Image-Assisted recall (camera) technology in nutrition and health analysis. Participants will select the target group, topic and nutrition challenge
- Five sections:
 1. Problem identification
 2. Target Group
 3. Location
 4. Study Design
 5. Expected Outcome

GUIDELINES

- Think of double burden of malnutrition
- Think of different age-groups and life stages
- Think of rural – urban
- Think of animal – human exchange of labour
- Which data can be triangulated with? Many dimensions: intra-household, labour, ill-health, adoption of technology... Think outside the box.

PART 4

EXPERIENCES FROM IMMANA FUNDED PROJECTS

ETHICAL CONSIDERATIONS WHEN USING TECHNOLOGIES

- Institutional Research Ethics Committees
- In-country Research Ethics Committees (accredited)
- Sensitization of communities - emphasize voluntary participation
- Data capture of non participants
- Capture of compromising/uncomfortable situations for participants
- Data usage and storage

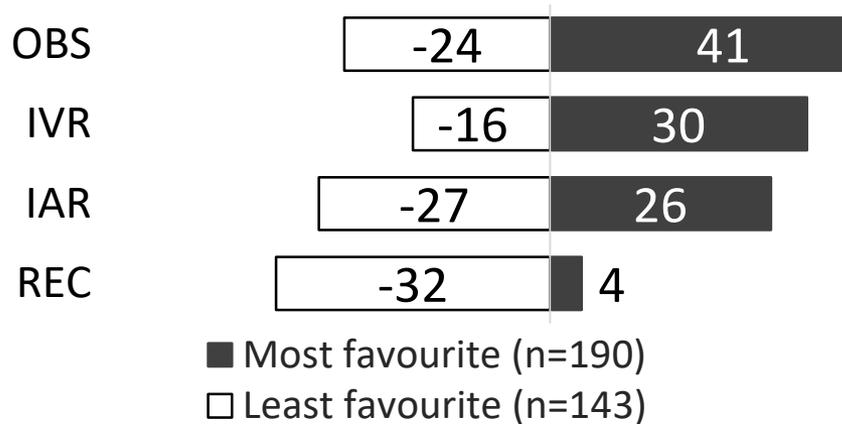
EXPERIENCES FROM IMMANA PROJECTS - ACCELEROMETERS IN LMICS

- Acceptability is context specific and conditional to successful engagement of the community
- Committed and well trained enumerators, suitable technologies, and robust protocol (regarding data and logistics) are central to feasibility
- Accelerometer devices are validated, yet not on activities related to rural livelihoods
- The technology lends itself to a wide range of contexts and research questions

INNOVATIVE METHODS FOR MEASURING DIETARY DIVERSITY AND TIME USE

Acceptability of methods

Preference of methods (%)



Respondent burden

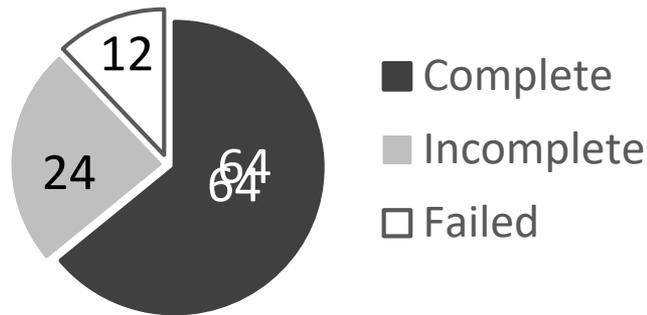
| Method | Median (IQR) |
|-------------------------------|------------------|
| IVR call duration | 15min (7min) |
| Observed period | 13h45min (47min) |
| Recall questionnaire duration | Approx. 1h |

5 respondents dropped out because:

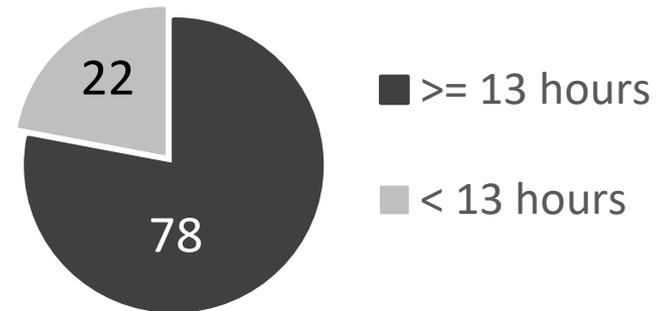
- Husband didn't agree to survey
- Illness
- Mistrust - 'INATU' was confused with 'illuminati'
- Belief that cameras may cause cancer

Challenges implementing methods

IVR response (%) (n=1251 calls)



LLWC achieving >13 hours (%) (n=207)



Interactive voice response

- Network connectivity (20%)
- Human issues (reported) (5%)
 - Interruptions by the child
 - illness
 - absence of the mother
 - mobile phone was switched off
 - panic or lack of practice

LLWC – Image assisted recall

- Problems with camera (reported) 10%
 - Camera needed replacing for 6 respondents
- Some images deleted for 5 respondents (latrine/children bathing)
- No respondent requested deleting of all images

Validity of results

| Life-logging wearable camera | Observation n=162 | 24-hour recall n=162 | Image-assisted recall n=162 |
|------------------------------|----------------------|-------------------------|--------------------------------|
| Maternal DDS, median (IQR) | 4 (2) | 4 (1) | 4 (1) |
| MDD ≥5 food groups, % | 41 | 46 ¹ | 43 |
| Child DDS, median (IQR) | 4 (1) | 4 (1) | 4 (1) |
| MDD ≥4 food groups, % | 54 | 59 | 57 |

¹ P-value of McNemar's chi2 of mean proportion difference against observation = 0.0412

| Interactive voice response | Observation n=82 | 24-hour recall n=82 | IVR* n=82 |
|----------------------------|---------------------|------------------------|--------------|
| Child DDS, median (IQR) | 4 (1) | 4 (1) | 3 (2) |
| MDD ≥4 food groups, % (n) | 59 | 58 | 49 |

*IVR underreporting of DDS & MDD due to underreporting of categories:

- Meat or fish
- Nuts & legumes
- Other fruit and vegetables

Discussion – IVR

Tackling response issues

- Several cards for network providers; use respondent's own phone
- Increase sample size; marginal costs relatively low (only requires sensitisation)
- For DDS:
 - Conduct just one call on following day
 - Repeat call at several points during day to ensure success

Reliability & Validity of DDS

- Results indicate the potential for accurate data collection
- However, extensive pre-testing of survey needed

Further opportunities

- Use IVR in combination with other data sources GPS and images

Discussion – LLWC-IAR

Continue using 24hr recall for DDS & MDD

- Validity of LLWC-IAR similar to 24HR recall for DDS and MDD
- LLWC-IAR is more resource intensive

Logistical challenges

- Camera positioning
- Poor lighting
- Communal food preparation (off-camera)
- Unlabelled & opaque food containers
- 30s interval still too long (esp. for incidental eating of child)
- No image recognition libraries (for AI)

Further opportunities

- Use images to quantify & illustrate GPS & IVR data (WIP)

PART 5