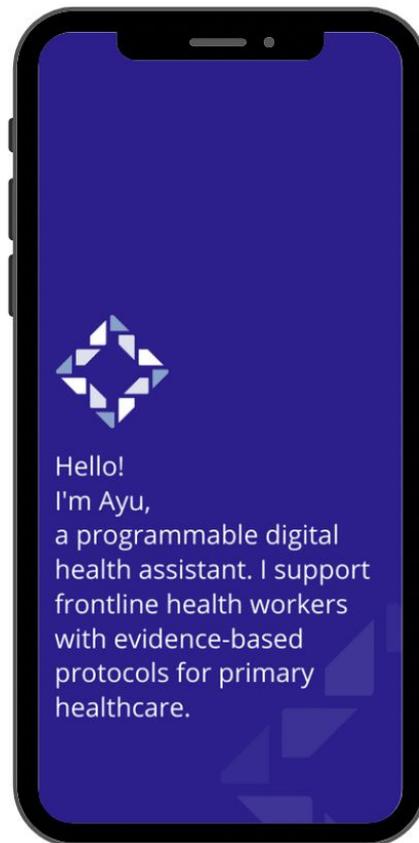


Meet Ayu

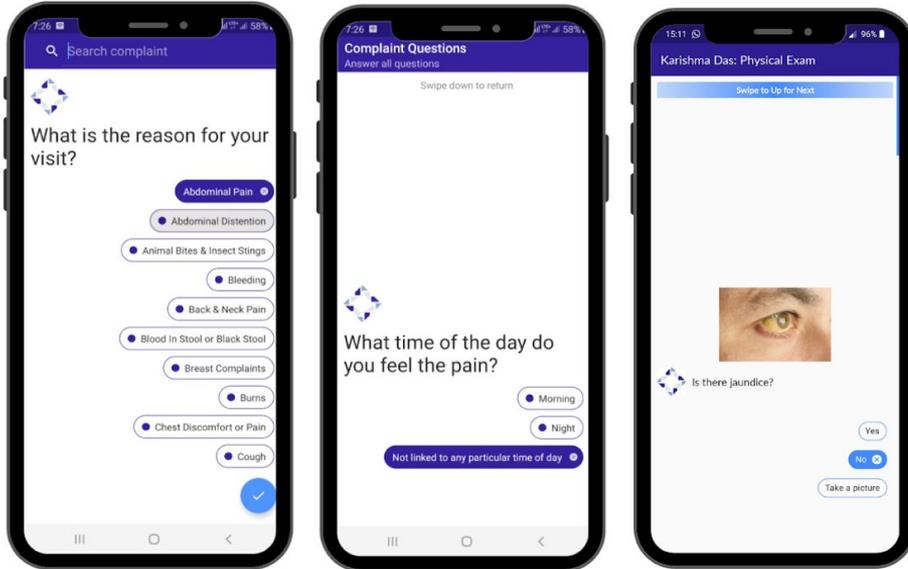


Why?

- In a telemedicine encounter, the patient-reported history is often the only clinical information available to the physician to make a diagnosis
- The medical history alone can lead to a diagnosis in 59-80% of cases, the physical exam can lead to a diagnosis in 8-20% of cases, and investigations in 8-20% of cases [1,2,3]
- Incomplete history taking is a leading factor contributing to diagnostic errors in telemedicine [4,5,6]
- Even in in-person care settings, a study by the World Bank shows that the average primary care consultation in India lasts 2.5 mins [7] and that in primary care clinics, licensed health care providers only completed between 16-22% of essential history-taking tasks [8,9].

What Ayu does

- Rules based clinical protocols for structured clinical data gathering
- Task shift clinical history taking to less busy health workers
- Improve quality of clinical information capture
- Improve the comprehensiveness of data capture
- Follow evidence-based clinical protocols for patient assessment & ensure critical questions are never omitted
- Added significance in an LMIC setting where diagnostic testing access is poor leading to a greater reliance by doctors on the patient history to make a diagnosis



Presenting Complaints

► Abdominal Pain:

- Site - Upper (R) - Right Hypochondrium.
- Pain does not radiate.
- Since 2 Years.
- Onset - Gradual.
- Timing - Not linked to any particular time of day.
- Character of the pain - Colicky / Intermittent (comes & goes), Dull, aching.
- Severity - Moderate.
- Exacerbating Factors - Food.
- Relieving Factors - None.
- Menstrual history - Menopausal
- Prior treatment sought - None.
- Additional information - Her weight is unchanged. she reports feeling full even after eating a moderate sized meal.

► Associated symptoms:

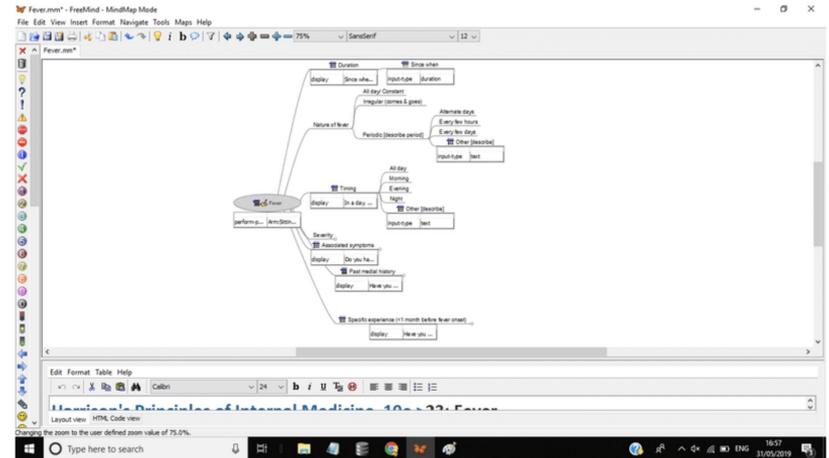
- Patient reports - Occasional migranes

About Ayu

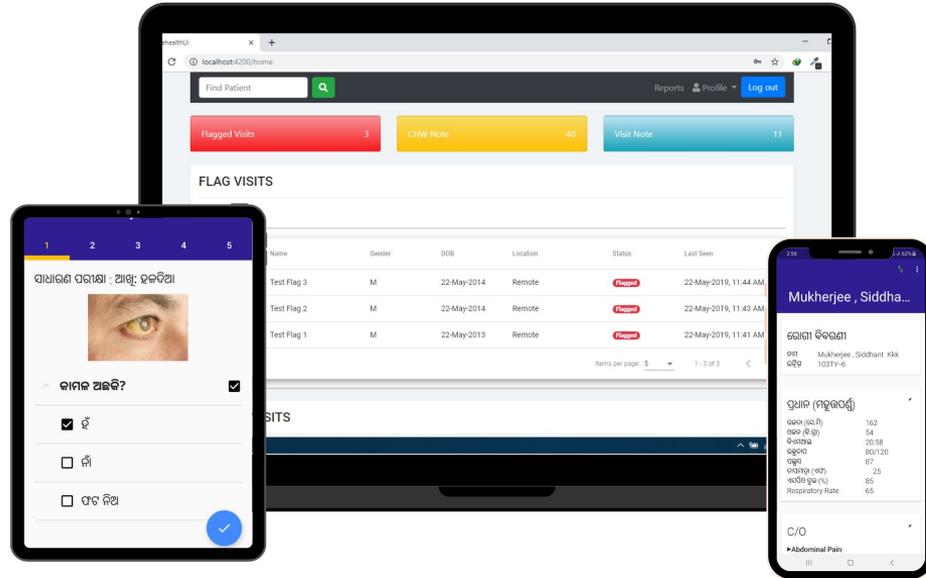
- 93 presenting complaints/clinical workflows developed & deployed
- Most available in 13 Indian languages
- Additional 70 are under development
- Over 1000+ history questions, 300+ physical exams
- Capture structured data, free text and images
- Multi-level adaptive logic questionnaires

About Ayu

- Multi-level adaptive logic questionnaires
- Built using mind maps
- Exported to JSON files that can be consumed by the Intellecthealth app
- Adaptable to context



IntelHealth: Digital Public Good for telemedicine



- [Link to Github](#)
- [Link to Wiki](#)

Goel NA, Alam AA, Eggert EMR, Acharya S. Design and development of a customizable telemedicine platform for improving access to healthcare for underserved populations. 2017 39th Annu Int Conf IEEE Eng Med Biol Soc. IEEE; 2017. p. 2658–2661. Verma N, Lehmann H, Alam AA, Yazdi Y, Acharya S

From data to intelligence

- Most healthcare data is unstructured!!!
- Structured data from Ayu can be used to,
 - Build rich data dashboards for program monitoring
 - Conduct disease surveillance
 - Predict disease risk
 - Train machine learning models
 - Simplify billing



Future work

- Patient-facing version of the digital assistant
- SDK for incorporating the assistant into any digital health app
- No code protocol builder
- More optimized questionnaires - improve precision (positive predictive value), improve recall (sensitivity) - reduce time and improve comprehensiveness
- Improved UI/UX
- Differential diagnosis engine (Rules based and AI based models) using the structured data
- Symptom coding in SNOMED
- Use of WHO SMART guidelines standards standards and FHIR compliance

Design

<https://humanfactors.jmir.org/2023/1/e25361>

Design requirements^[10]

Design considerations for health organizations

- Standardization of service delivery
- Monitor FHW & doctor performance & adherence to protocols
- Evidence-based approach
- Minimize patient safety risks
- Minimize regulatory risks
- Improve program adoption



Design considerations for remote doctors

- Receive accurate medical information about the patient
- Information should be sufficient to arrive at a differential diagnosis
- Patient note should be succinct & easy to read
- Minimal irrelevant information
- Matching with teleconsult requests as per specialty & availability

Design considerations for patients

- Native language
- Simple locally relevant terminology
- Responsive to patient's emotions & able to influence behavior
- Promote trust & satisfaction



Design considerations for FHWs

- Simple & intuitive user experience
- Native language
- Job aids
- Improve confidence
- Improve capacity
- Portable & uses less power
- Works offline/ over low bandwidth internet

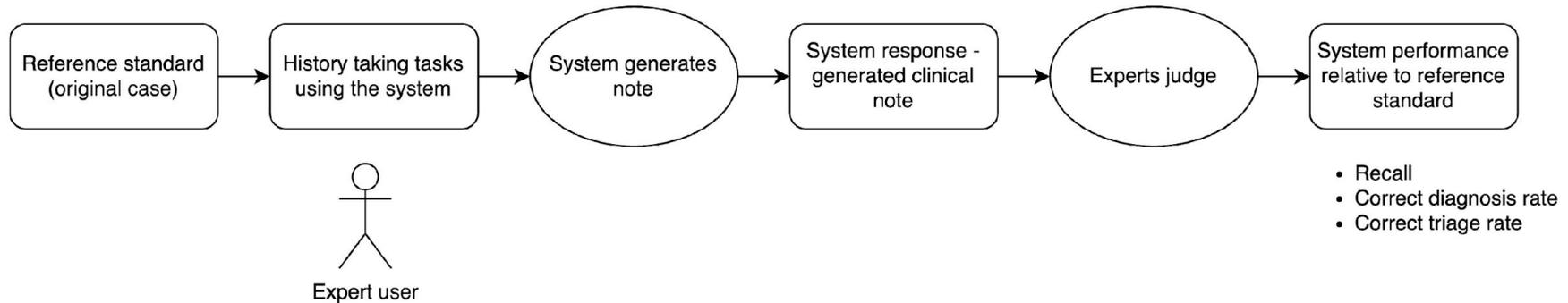


Process of Knowledge acquisition to develop task shifting protocols to collect patient information [10]

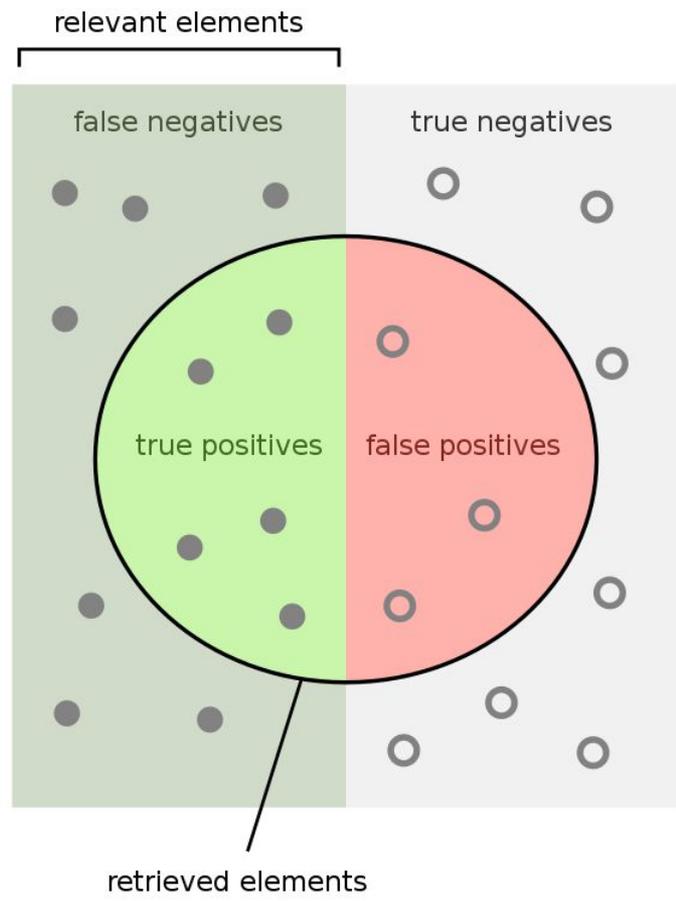
No.	Stage	Result
1.	Identified symptom list to cover the scope of most prevalent presenting complaints through literature review	67 presenting complaints identified
2.	Created data collection questionnaires to collect subjective data for the presenting complaints through a literature review and synthesis of evidence-based guidelines	67 data collection questionnaires compiled
3.	Identified simple physical exams to collect objective data and map them to complaints	143 exams identified
4.	Contextualized questionnaires to the etiology & epidemiology of disease in India.	67 questionnaires contextualized
5.	Feasibility assessment to remove history-taking questions & physical exams that are difficult to task shift to health workers or have a high burden of training	Questionnaire list reduced to 51, exam list reduced to 93
6.	Translation of content into local language and adaptation to improve comprehensibility for patients	Translations complete & verified. 51 questionnaires & 93 physical exams modified.
7.	Adaptations to local social and cultural contexts	Adaptations complete & verified. 51 questionnaires & 93 physical exams modified.

Evaluation

Evaluation of information retrieval ability of Ayu



- Recall (Sensitivity) = $TP / TP + FN$



How many retrieved items are relevant?

$$\text{Precision} = \frac{\text{true positives}}{\text{true positives} + \text{false positives}}$$

How many relevant items are retrieved?

$$\text{Recall} = \frac{\text{true positives}}{\text{true positives} + \text{false negatives}}$$

Hx

A 49-year-old woman is referred for the evaluation of a 2-year history of upper gastrointestinal discomfort. She describes a daily, persistent ache or discomfort that waxes and wanes. She complains that eating tends to worsen her pain and that she feels very full, even after eating only a modest-sized meal. Her weight is unchanged, and her medical history is notable only for occasional migraine headaches. Her surgical history includes an appendectomy (age 7) and wisdom teeth extraction (age 16). She does not use tobacco products and rarely drinks alcohol. Her family history is noncontributory. She is an appropriate, interactive woman (body mass index [BMI] is 23.4 kg/m). Physical examination is notable only for mild epigastric tenderness to palpation. There is no evidence of ascites, organomegaly, a succussion splash, abdominal mass, or bruit. An upper gastrointestinal (UGI) series (2 years ago), abdominal ultrasound and hepatobiliary iminodiacetic (HIDA) scan (18 months ago), upper endoscopy (12 months ago), and 4-h solid-phase gastric emptying scan (4 months ago) were normal. She is *Helicobacter pylori*-negative. Extensive laboratory tests (complete blood count [CBC], erythrocyte sedimentation rate [ESR], liver function tests [LFTs], lipase, and electrolytes) have all been normal on at least two occasions. The patient asks you what her diagnosis is and how her symptoms can be treated.

Captured information Hx

Missing information Hx

Captured information Px

Missing information Px

► Abdominal Pain:

- Site - Upper (C) - Epigastric.
- Pain does not radiate.
- 2 Years.
- Timing - Daily persistent pain or discomfort that waxes and wanes.
- Character of the pain - Dull, aching.
- Exacerbating Factors - Food, She complains that she feels very full, even after eating only a modest sized meal.
- Associated symptoms:
 - Patient reports - Occasional migraine headaches.

Family History

Past Medical History

- Alcohol use - Yes - Rarely .
- Smoking history - Patient denied/has no h/o smoking.
- Operation - Location/Type, Appendectomy at 7 years. , Occured on.

Vitals

Temp: Height: 154 cm Weight: 55.5 kg BMI: 23.40 SP02: %BP: / HR: RR:

On Examination

General exams:

- Eyes: Jaundice-Don't know.
- Eyes: Pallor-Don't know.
- Arm-Pinch skin* - Don't know.
- Nail abnormality-Don't know.
- Nail anemia-Don't know.
- Ankle oedema-Don't know.

Results

Mean
Recall

Patient history = 0.65 ± 0.19
(n=190) or 65%

Mean
Recall

Physical exam = 0.42 ± 0.28
(n=174) or 42%

Correct
Dx rate

68%

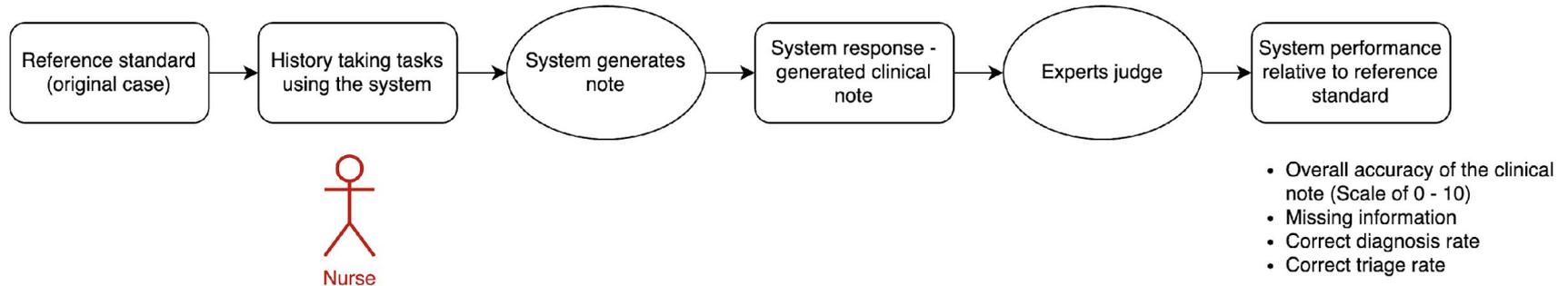
Correct
triage
rate

88%

Table 3: Mean recall for patient history and physical exams

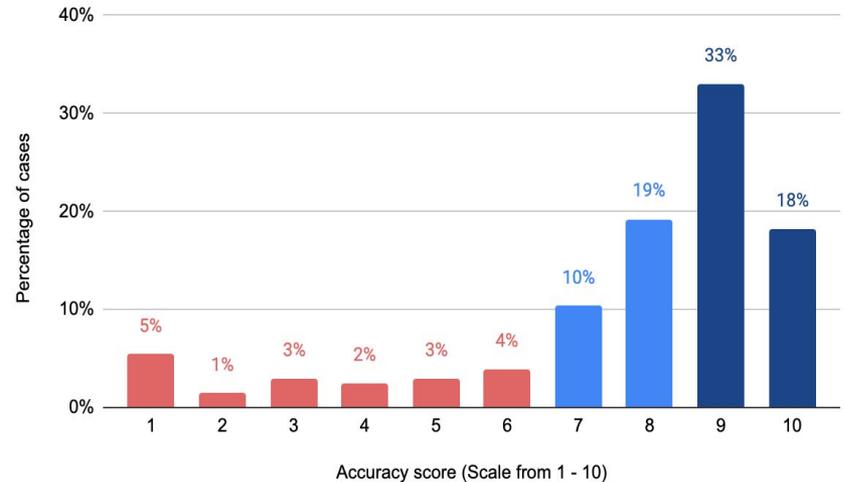
	Mean recall \pm std dev (Patient history)	Mean recall \pm std dev (Physical exam)	Correct triage rate	Correct diagnosis rate
Overall	0.65 ± 0.19 (n=190)	0.42 ± 0.28 (n=174)	88%	68%
High prevalence	0.64 ± 0.22 (n=101)	0.44 ± 0.29 (n=92)	92%	92%
Moderate prevalence	0.62 ± 0.16 (n=46)	0.41 ± 0.28 (n=44)	89%	48%
Low prevalence	0.71 ± 0.15 (n=43)	0.38 ± 0.26 (n=38)	79%	35%
Infectious diseases	0.62 ± 0.21 (n=54)	0.46 ± 0.28 (n=50)	87%	78%
Gastroenterology	0.63 ± 0.16 (n=28)	0.40 ± 0.26 (n=27)	89%	43%
Cardiology	0.70 ± 0.18 (n=16)	0.44 ± 0.32 (n=16)	75%	69%
General medicine	0.67 ± 0.18 (n=15)	0.28 ± 0.33 (n=11)	100%	93%
Dermatology	0.64 ± 0.28 (n=13)	0.46 ± 0.36 (n=13)	77%	77%
Pulmonology	0.60 ± 0.07 (n=12)	0.50 ± 0.13 (n=12)	83%	17%
Endocrinology	0.56 ± 0.19 (n=10)	0.29 ± 0.09 (n=10)	90%	100%
Nephrology	0.58 ± 0.13 (n=8)	0.38 ± 0.12 (n=7)	88%	75%
Pediatrics	0.72 ± 0.15 (n=8)	0.53 ± 0.25 (n=6)	100%	50%
Neurology	0.69 ± 0.19 (n=7)	0.47 ± 0.29 (n=6)	100%	71%
Gynecology	0.90 ± 0.13 (n=6)	0.61 ± 0.54 (n=3)	100%	50%
Hematology	0.84 ± 0.08 (n=6)	0.41 ± 0.25 (n=6)	83%	83%
Orthopedics	0.64 ± 0.19 (n=5)	0.19 ± 0.24 (n=5)	100%	100%
Ophthalmology	0.54 ± 0.35 (n=2)	0.36 ± 0.51 (n=2)	100%	50%

2b: Evaluation of fidelity of use by nurses



Results

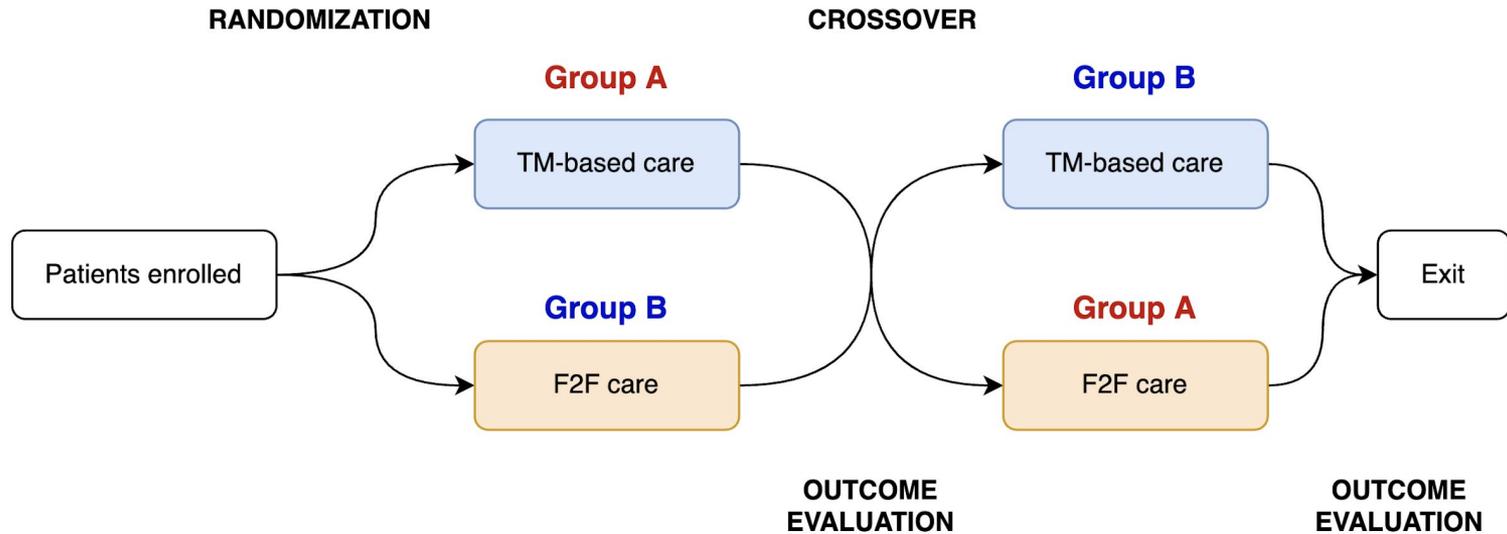
- Mean Accuracy = 7.71 ± 2.42 (n= 203)
- Correct diagnosis rate = 74%
- Correct triage rate = 85%
- 58% (n=117) cases had no information missing, 17% (n=34) had some information missing that did not impact the diagnosis and 26% (n=52) had important information missing that would have changed the patient's diagnosis



Proportion of cases with high (9 or 10), acceptable (7 or 8), and poor (6 or below) accuracy scores

Randomized cross over study comparing diagnosis & treatment outcomes of TM vs F2F care^[11]

- 10 clinics in rural Gujarat, Sample size 104 patients, patient-diagnosis pair (n=?)
- Methods: Outcomes – TM vs F2F – Dx, Tx and Hx



Telemedicine gives similar outcomes to F2F care

- 74% diagnostic concordance
- 80% treatment concordance
- No significant association was found between diagnosis and treatment concordance and
 - the order of consultation
 - FHW-doctor pair
 - Gender
 - mode of teleconsultation

(Fisher's exact test, $p > 0.05$)

	No. of patients (n)	Percentage (%)	Diagnosis concordance (% agreement)	p-value* (two-sided)	Treatment concordance (% agreement)	p-value* (two-sided)
Order of consultation	104	100%	74% (n=77)	p = 0.653	80% (n=83)	p = 0.806
F2F consultation first	59	57%	76% (n=45)		81% (n=48)	
TM consultation first	45	43%	71% (n=32)		78% (n=35)	
Location/CHO-doctor pair	104	100%	74% (n=77)	p = 0.932	80% (n=83)	p = 0.929
HWC 1	11	11%	73% (n=8)		91% (n=10)	
HWC 2	11	11%	73% (n=8)		82% (n=9)	
HWC 3	8	8%	50% (n=4)		63% (n=5)	
HWC 4	10	10%	70% (n=7)		80% (n=8)	
HWC 5	10	10%	70% (n=7)		70% (n=7)	
HWC 6	10	10%	80% (n=8)		80% (n=8)	
HWC 7	13	13%	85% (n=11)		85% (n=11)	
HWC 8	9	9%	78% (n=7)		89% (n=8)	
HWC 9	11	11%	82% (n=9)		82% (n=9)	
HWC 10	11	11%	73% (n=8)		73% (n=8)	
Gender	104	100%	74% (n=77)	p = 1.000	80% (n=83)	p = 1.000
Female	70	67%	74% (n=52)		80% (n=56)	
Male	34	33%	74% (n=25)		79% (n=27)	
Mode of teleconsultation	100	100%	73% (n=73)	p = 0.317	79% (n=79)	p = 0.294
Asynchronous	84	84%	71% (n=60)		77% (n=65)	
Synchronous	16	16%	81% (n=13)		88% (n=14)	

*Fisher's exact test was used to determine if there was a significant association between diagnosis and treatment concordance and the order of consultation, CHO-doctor pair, gender, type of case and mode of teleconsultation

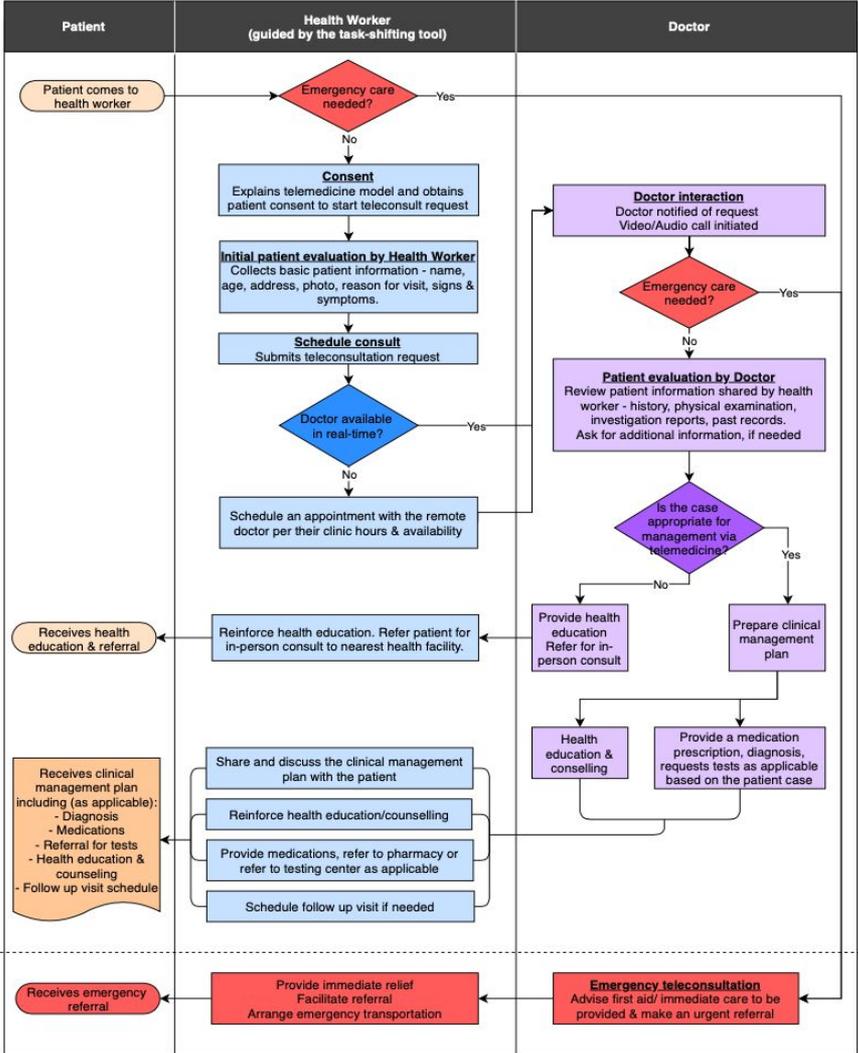
Telemedicine outcomes depend on the type of case

- A significant association was found between diagnosis and treatment concordance and the case specialty (Fisher's exact test, $p < 0.05$)
 - High concordance seen in Hypertension, Diabetes, Obstetrics, Pediatrics, Orthopedics
 - Cohen's Kappa for diagnosis of diabetes = 0.93
 - Cohen's Kappa for diagnosis of hypertension = 0.89
 - Low concordance seen in Dermatology, Gynecology, Cardiology, Non-specific illnesses

- Cannot conclude due to low sample sizes

Type of case/Specialty	No. of patients (n)	Percentage (%)	Diagnosis concordance (% agreement)	p-value* (two-sided)	Treatment concordance (% agreement)	p-value* (two-sided)
Type of case/Specialty	113	100%	74% (n=113)	p = 0.004	80% (n=90)	p = 0.028
Hypertension	21	19%	95% (n=20)		95% (n=20)	
Diabetes	15	13%	93% (n=14)		93% (n=14)	
Obstetrics	10	9%	80% (n=8)		80% (n=8)	
Pediatrics	17	15%	76% (n=13)		88% (n=15)	
Orthopedics	18	16%	72% (n=13)		78% (n=14)	
Gastroenterology	6	5%	67% (n=4)		67% (n=4)	
Dermatology	8	7%	63% (n=5)		75% (n=6)	
Gynecology	5	4%	60% (n=3)		60% (n=3)	
Cardiology	3	3%	33% (n=1)		33% (n=1)	
Miscellaneous	10	9%	30% (n=3)		50% (n=5)	

*Fisher's exact test was used to determine if there was a significant association between diagnosis and treatment concordance and the order of consultation, CHO-doctor pair, gender, type of case and mode of teleconsultation



Step 1: Vitals

Step 4: Further probing into any associated symptoms

Step 7: Physical exams

Step 2: Select presenting complaints

Step 5: Past Medical History

Step 8: Upload any relevant physical exam images

Step 3: Answer questionnaire about the presenting complaint

Step 6: Family History

Step 9: Upload any lab test reports

Step 10: Final output clinical note

Visit details

Name: Ramesh Kumar
ID: 101P-3
Visit ID: XXX00b3c

Vitals

Height (cm): 168
Weight (kg): 72
BMI: 25.51
BP: 130/85
Pulse: 75
Temperature (F): 99.0
SpO2 (%):
Respiratory Rate:

Reason for visit

- Abdominal Pain:**
 - Site - Upper (C) - Epigastric, Middle (C) - Umbilical.
 - Pain radiates to - Right shoulder.
 - 5 hours.
 - Onset - Regularly increasing.
 - Timing - Night.
 - Character of the pain - Cramping.
 - Severity - Severe: 7/10.
 - Exacerbating Factors - Pressure, Movement, Coughing, Straining.
 - Relieving Factors - Laying forward, Squatting.
 - Prior treatment sought - None.
- Additional information -**
- Back & Neck pain**
- Associated symptoms:**
 - Patient reports Abdominal distention/Bloating, Belching/Burping, Passing gas.
 - Patient denies Nausea, Vomiting, Anorexia, Diarrhea, Constipation, Fever, Color change in stool [described], Blood in stool.

On examination

General exam:

- Eyes: Jaundice no; jaundice seen.
- Eyes: Pallor-normal pallor.
- Arm-Flexor sites - pinch test normal.
- Nail abnormality- nails normal.
- Nail events-Nails are not pale.
- Ankle-no pedal oedema.

Leg:

- Strength both legs have equal strength.

Abdomen:

- tenderness seen - location - Middle(L).
- Lumps no lumps.
- distension seen.
- no scanning.

Back:

- Patient can bend forward properly from the waist.
- no back tenderness.
- no visible spinal deformity.
- no redness seen.
- no swelling seen.

Medical history

- Pregnancy status - Not pregnant.
- Allergies - No known allergies.
- Alcohol use - No/ Denied.
- Smoking history - Patient denied/has no h/o smoking.
- Drug history - Amplicipive 5mg since 1 year.
- High Blood Pressure - 08/Aug/2019.
- Asthma - 14/May/2014.

References

1. Roshan M, Rao AP. A Study on Relative Contributions of the History, Physical Examination and Investigations in Making Medical Diagnosis. *J Assoc Physicians India*. 2000;48(8):771–775. PMID: 11273467
2. Peterson MC, Holbrook JH, Hales D Von, Smith NL, Staker L V. Contributions of the history, physical examination, and laboratory investigation in making medical diagnoses. *West J Med*. BMJ Publishing Group; 1992;156(2):163. PMID: 1536065
3. Hampton JR, Harrison MJ, Mitchell JR, Prichard JS, Seymour C. Relative contributions of history-taking, physical examination, and laboratory investigation to diagnosis and management of medical outpatients. *Br Med J*. BMJ Publishing Group; 1975;2(5969):486. PMID: 1148666
4. Katz HP, Kaltsounis D, Halloran L, Mondor M. Patient Safety and Telephone Medicine. *J Gen Intern Med*. Springer-Verlag; 2008;23(5):517–522. PMID: 18228110
5. Resneck JS, Abrouk M, Steuer M, Tam A, Yen A, Lee I, et al. Choice, Transparency, Coordination, and Quality Among Direct-to-Consumer Telemedicine Websites and Apps Treating Skin Disease. *JAMA dermatology*. American Medical Association; 2016;152(7):768–75. PMID: 27180232
6. Schoenfeld AJ, Davies JM, Marafino BJ, Dean M, DeJong C, Bardach NS, et al. Variation in Quality of Urgent Health Care Provided During Commercial Virtual Visits. *JAMA Intern Med*. American Medical Association; 2016;176(5):635.
7. Irving G, Neves AL, Dambha-Miller H, Oishi A, Tagashira H, Verho A, et al. International variations in primary care physician consultation time: A systematic review of 67 countries. *BMJ Open*. 2017. PMID: 29118053
8. Das J, Holla A, Mohpal A, Muralidharan K. Quality and Accountability in Health Care Delivery: Audit-Study Evidence from Primary Care in India. *Am Econ Rev*. 2016;106(12):3765–99. PMID: 29553219
9. Das J, Holla A, Das V, Mohanan M, Tabak D, Chan B. In urban and rural India, a standardized patient study showed low levels of provider training and huge quality gaps. *Health Aff (Millwood)*. NIH Public Access; 2012;31(12):2774–84. PMID: 23213162
10. Verma N, Lehmann H, Alam AA, Yazdi Y, Acharya S. Development of a digital assistant to support teleconsultations between remote doctors and frontline health workers in India: A User-centered Design Approach. *JMIR Human Factors*. 10/09/2022:25361 (forthcoming/in press)
11. Verma N, Buch B, Taralekar R, Acharya S. Diagnostic concordance of telemedicine as compared to face-to-face care in primary health care clinics in rural India: a randomized crossover trial. *JMIR Preprints*. 17/09/2022:42775