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Bridging Patient Records and Medicine Supply Chains: A Review of Digital Health Systems in Indian Primary Healthcare

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Abstract - Primary health centres in India are slowly moving patient records and medicine stock management onto digital systems, but there are few field accounts of how this works in busy, low-resource clinics. This review compares two such accounts: an ethnographic study of a patient-centric electronic health record (IHIS4PHC) at an urban primary care centre in Chandigarh, and a benefit evaluation of e-Aushadhi, the drug inventory system run by the Rajasthan government. We re-read both papers under six common headings: system design, implementation support, staff perception, patient experience, measured outcomes and remaining barriers. Both systems reduced duplicate paperwork and made reporting easier, although staff in Chandigarh found data entry slow and rigid in the early months. The systems differ mainly in what they cover. IHIS4PHC holds patient records and an in-clinic stock module but has no link to district procurement. e-Aushadhi runs procurement and warehouse distribution but holds no patient clinical record. Neither passes clinical data into an estimate of local medicine demand. The evidence base is small and our conclusions are tentative, but the gap is clear enough to justify work on connected systems. We also draw out design requirements for such a system from the barriers the two studies report.

Key Words: Primary healthcare, digital health, electronic health records, drug supply chain, e-Aushadhi, India.

1. INTRODUCTION

Most outpatient care in India is delivered at the primary level, and this is also where digital systems have been slowest to settle in. Weak internet connectivity, irregular electricity and staff who find the software hard to use have all been reported [1]. A 2018 review of mHealth work in India shows a similar picture from a wider angle. Of the 125 primary studies it examined, 57.6% were aimed at service delivery, most relied on convenience sampling, and most of the interventions ran as stand-alone tools with no plan for fitting into the wider health system [2].

The policy context has pushed in the same direction. The National Health Policy 2017 envisages assured comprehensive primary care, including free essential medicines and diagnostics in public facilities [3], and the Ayushman Bharat programme has since set out to convert sub-centres and primary health centres into Health and Wellness Centres [4]. Both commitments depend on information. A centre that cannot say how many people with hypertension it follows up, or how many tablets it dispensed last month, cannot plan, and a state that promises free medicines needs to know which ones are running low. Surveys of public facilities have also shown that the availability of medicines is uneven, with some classes widely stocked and others rarely found [5].

Two kinds of digital system operate at this level. One is built around the patient and covers registration, prescriptions and follow-up of chronic conditions. The other is built around medicines and covers procurement, warehouse stock and distribution to facilities. They are usually designed, funded and written up separately. From the published work we could read, it was hard to tell whether any system follows a patient from the consulting room to the medicine counter and then back to the warehouse.

The distinction between the two kinds of system matters because the two halves depend on each other. What a clinic prescribes today becomes what a warehouse must supply next month, and what a warehouse cannot supply limits what a clinic can prescribe. When the two are recorded in separate systems, the link has to be made by people through whatever informal means are available. That can work for a single centre. It becomes harder to sustain across a district, and it leaves the clinical record unused for the one purpose, forward planning of stock, for which it is best placed.

This paper looks closely at one example of each. IHIS4PHC (Integrated Health Information System for Primary Health Care) was introduced at a primary care centre serving about 25,000 people in an urban slum area of Chandigarh, and was studied through interviews, focus groups and observation [1]. e-Aushadhi is the drug inventory system run by the Rajasthan Medical Services Corporation since 2011, and has been assessed with a benefit evaluation framework [6]. Between them they cover most of a typical visit, from registration to dispensing and reordering, yet neither study describes a system that covers both ends.

Our aim was to compare what the two studies report about design, adoption, benefits and problems, and to see where the boundary between them leaves a gap. This matters for anyone planning a connected system that would link patient-level clinical data with local medicine demand.

Three questions guided the review. First, how did each system treat the design of its core records and workflows? Second, what did staff and beneficiaries report about adoption, benefits and difficulties? Third, where does the boundary between a patient-centric and a medicine-centric system lie in these two cases, and what would it take to cross it?

The contribution of the paper is a structured side-by-side reading of the two cases, together with a set of design requirements for a connected system drawn from the barriers they report. The rest of the paper is organised as follows.

Section 2 gives background and related work, Section 3 describes the review method, Section 4 presents the thematic synthesis, Section 5 discusses the findings, Section 6 draws out design implications, Section 7 sets out a research agenda, and Sections 8 and 9 give the limitations and conclusions.

2. BACKGROUND AND RELATED WORK

2.1 Primary care delivery in India

Public primary care in India is organised in tiers. Sub-centres and primary health centres sit closest to the community, with community health centres and district hospitals above them for referral. A typical primary health centre is staffed by a medical officer, nurses, a pharmacist and field workers such as auxiliary nurse midwives and multipurpose workers, who share registration, consultation, dispensing, outreach and reporting between them. The studies reviewed here describe this mix of roles clearly, with community physicians, auxiliary nurse midwives and multipurpose workers all appearing in the Chandigarh account [1]. Since 2018 the Health and Wellness Centre model has widened the package of services at this level to include screening and long-term care for non-communicable diseases [4]. This increases the amount of follow-up data a centre must hold and the amount of medicine it must keep in stock.

2.2 Digital health policy

Digital health in India has moved from isolated projects towards a national architecture. The EHR Standards published by the Ministry of Health and Family Welfare in 2016 recommended common standards for the content and exchange of health records [7]. The Ayushman Bharat Digital Mission, rolled out nationally from 2021, aims to provide digital health identifiers, registries of facilities and professionals, and consent-based sharing of records across providers [8]. As far as we could tell from public descriptions, these efforts focus on the patient record and its portability, and say less about how a clinical record should inform the stock of medicines in the same facility. Alongside them, the Digital Personal Data Protection Act, 2023 sets the legal terms for processing personal data [9], and any system that moves clinical information beyond the clinic will have to be designed around it.

2.3 Medicine availability and supply chains

Availability of medicines in public facilities has long been a concern. A survey of 80 public health facilities in 12 districts of Haryana and Punjab found that availability varied by medicine class and by level of facility, and that some classes, including anti-cancer, thrombolytic and endocrine medicines, were available in less than 30% of public facilities [5]. The same study examined storage and inventory systems, a reminder that availability depends on how stock is recorded as well as on what is bought. Several states have set up central procurement bodies to buy and distribute medicines, and the Rajasthan Medical Services Corporation, which runs e-Aushadhi, is one of them [6].

Digital tools are attractive in this area because stock is easy to count and expiry dates can be tracked. The WHO guideline on digital interventions for health system strengthening recommends stock notification and commodity management by mobile devices only in settings where supply chain systems can respond to the notifications in good time, and it points out that a notification alone does not improve availability [10]. A digital stock count therefore helps only if something downstream acts on it.

2.4 Frameworks for adoption and success

Studies of health information systems tend to ask one of two questions: why do people use a system, and does the system work? The first is usually answered with behavioural models. The Theory of Interpersonal Behaviour, which the Chandigarh authors cite through Gagnon et al. [11], links intention and behaviour to attitudes, social factors, habits and facilitating conditions. The COM-B model proposes that behaviour arises from capability, opportunity and motivation [12]. The unified theory of acceptance and use of technology combines earlier models into constructs such as performance expectancy, effort expectancy, social influence and facilitating conditions [13].

The second question is usually answered with success models. DeLone and McLean's model relates system quality, information quality and service quality to use, user satisfaction and net benefits [14], and the benefit evaluation framework applied to e-Aushadhi builds on this tradition [15]. A third family of work asks why technologies fail to spread or are abandoned after a pilot. The NASSS framework treats the technology, the adopters, the organisation and the wider system as sources of non-adoption, abandonment and failure to scale [16]. We use these frameworks as a source of vocabulary and not as tests to be passed, since neither source study was designed around all of them.

2.5 Positioning of this review

Work on integrated health information architecture argues for bringing data from separate programmes onto shared platforms that serve local users first [17]. Our question is a narrower version of that argument: whether the patient record and the medicine ledger at a primary care centre should be treated as parts of one architecture. The two studies we reviewed do not ask this question themselves. We ask it of them.

3. METHODS

3.1 Selection of studies

We chose two peer-reviewed Indian field studies: Faujdar et al. on IHIS4PHC, published in Healthcare Informatics Research [1], and Mantri et al. on e-Aushadhi, published in the Journal of Family Medicine and Primary Care [6]. A study was included if it (a) described a digital health system in actual use at primary-care or district level, (b) reported first-hand data from users or system records, and (c) evaluated the system with a named framework. We did not run a systematic database search. Two further papers were used for background only: a systematic review of the management literature on digital health [18] and the systematic review of mHealth in India mentioned above [2]. They help place the two case studies in context and were not merged with them.

3.2 Comparison framework

The two studies used different evaluation tools. Faujdar et al. analysed their data thematically and then interpreted it through the Theory of Interpersonal Behaviour [11] and the COM-B model [12]. Mantri et al. used a benefit evaluation framework with six dimensions, which builds on DeLone and McLean's information systems success model [15]. Applying either framework to both papers would have forced findings into categories the authors did not use. Instead we picked six headings that both papers could be read against: system design,

implementation support, staff perception and adoption, patient or beneficiary experience, measured outcomes, and remaining barriers. Table 1 summarises the two studies, and Sec. 4 goes through the headings in turn.

3.3 Data extraction

For each study we extracted, under each of the six headings, what the authors reported directly, what they quoted from participants and what they inferred. We kept three kinds of statement apart in the synthesis: figures taken from system records (for example counts of beneficiaries), estimates given by staff (for example the time taken to find a record) and interpretations offered by the authors (for example that higher spending on medicines suggests lower out-of-pocket payment). We did not score the studies with a formal appraisal tool, because the two designs, an ethnography and a mixed-methods benefit evaluation, do not share one. Instead we noted for each study the size of its sample, whether it had a comparison group and whether outcomes were measured or only reported.

3.4 Rationale for a paired comparison

A two-case comparison cannot support claims about how common a problem is, but it suits a question about structure. IHIS4PHC and e-Aushadhi were chosen because each covers one end of the visit to a depth the other does not, and each has a field evaluation with a named framework. If a gap is visible between two well-documented systems at opposite ends of the pipeline, it is at least a gap worth testing in a larger sample. We therefore treat the findings as hypotheses for later work and not as estimates.

3.5 Terms used

Throughout the paper a patient-centric system is one organised around the individual patient's record and visits, and a medicine-centric system is one organised around stock, procurement and distribution. Demand means the quantity of a medicine needed over a period by the people a centre serves, while consumption means the quantity actually dispensed. The two differ whenever stock runs out. A stock-out is a period during which a medicine that should be available is not. OPD and IPD refer to outpatient and inpatient departments.

Table -1: Comparison of the two systems reviewed

Feature	IHIS4PHC (Chandigarh) [1]	e-Aushadhi (Rajasthan) [6]
Setting	One primary care centre serving about 25,000 people in an urban slum area, 2017–18	District Drug Warehouse network, Jodhpur district; data from 2015 to 2020
What it digitises	Patient records, prescriptions, follow-up, SMS reminders, in-clinic medicine stock	Procurement, warehouse stock, issue to public facilities, expiry tracking
Study design	Ethnographic: 3 focus groups (20 clients), 6 in-depth interviews with staff, participant observation	Mixed methods: stakeholder interviews, dashboard data, document review
Evaluation lens	Theory of Interpersonal Behaviour and COM-B [11], [12]	Benefit evaluation framework, six dimensions [15]
Reported gains	Faster record search, fewer duplicate entries, preventive and curative care in one record	Response time down from 6–7 to 3–4 months; more OPD and IPD beneficiaries
Reported problems	Slower data entry, rigid fields, paper registers still required, power cuts	Need for fibre connectivity, trained staff and public awareness
Link to the other half	In-clinic stock only; no link to district procurement or demand planning	No patient clinical record; demand read from consumption data

4. THEMATIC SYNTHESIS

4.1 System design

IHIS4PHC was built on two open-source platforms, OpenMRS and DHIS2, and organised patient data around a household-level "Family Folder" that linked each member to modules for antenatal care, immunisation, non-communicable diseases and outpatient records [1]. It also carried a medicine inventory for the centre. e-Aushadhi has three tiers, a database server, an application server and a client interface, with purchase orders moving from the state corporation to district warehouses and demand generated from facility data [6]. One system had to represent a person and their history, the other a stock ledger and a supply route. Neither paper describes a point where the two meet.

The design choices carry consequences. A household-level folder suits long-term follow-up because the members of a family can be seen together, which helps with antenatal care, immunisation and chronic conditions [1]. A three-tier procurement system suits bulk purchasing and audit, since each tier has a clear role and purchase orders follow a fixed path [6]. Each design fits its own job well. The difficulty lies in what each leaves out: a household folder has no notion of a supplier, and a purchase order has no notion of a patient. Any connection between them would need a deliberately chosen middle layer, such as aggregated counts of patients on treatment, and not a direct merge of the two databases.

4.2 Implementation support

Both studies link early use to hands-on support. In Chandigarh a software developer and a technical assistant worked alongside staff during the rollout, explained each module as it was added and fixed problems on the spot, yet staff still relied on the technical assistant even for minor troubleshooting [1]. In Rajasthan the IT department runs annual workshops, new joiners are trained by the existing informatics assistant, and SMS and WhatsApp groups are used to pass on information quickly [6]. The Chandigarh authors credit continuous hands-on support with changing staff perceptions [1], and the Rajasthan authors list continuous training among the things still needed [6].

The two accounts describe different kinds of support. In Chandigarh it was close and personal, with developers present in the centre. In Rajasthan it was institutional, built on annual workshops, peer training and messaging groups [6]. Each has a cost. Close support is hard to extend beyond a pilot site, and the reliance on the technical assistant even for minor problems suggests that skills did not fully transfer [1]. Institutional support scales better but, as the Rajasthan authors note, needs to

be kept going through continuous training [6]. A connected system would probably need both: an on-site first line for the opening months and a standing training route for staff who join later.

4.3 Staff perception and adoption

In Chandigarh, community physicians found it cumbersome to pick the medicine name, composition, dose and frequency from separate drop-down menus, and consultations took about two minutes longer per patient [1]. The system also required socio-demographic fields that could simply be left blank on paper. Auxiliary nurse midwives had to keep paper registers as well, because the state administration still asked for them, so two systems ran side by side [1]. After some months of use, staff said that searching records and producing reports had become much easier, and that the time they used to spend entering the same details in several registers, more than half of their working time, could now go to patient care [1].

In Rajasthan, most of the stakeholders interviewed were satisfied and said their work had become more efficient [6]. An assistant programmer said paperwork had come down but that a dedicated fibre network was needed for uninterrupted use, and an administrator named under-used infrastructure and human resources, and low public awareness, as the main constraints [6].

Several of the adoption problems in Chandigarh were problems of fit between the software and the work. Separate drop-down menus for name, composition, dose and frequency mirror the way a database stores a prescription more than the way a physician thinks of one, and the extra two minutes per patient [1] is a real cost in a busy outpatient clinic. Parallel paper registers meant that the digital record added work before it saved any [1]. This ordering, cost first and benefit later, may explain why early evaluations of such systems can look worse than later ones.

The Chandigarh study also found a less comfortable side. Staff said they were now questioned more often about mismatches in their records, and some described this as surveillance, which the authors list as one reason for resisting the system [1]. Some also worried about depending on the computer, since a failure would stop outpatient work [1]. The e-Aushadhi paper describes monitoring tools such as double prescription slips, prescription and financial audits and a complaint desk [6], but it does not report how staff felt about them.

The surveillance concern is a different kind of problem. It reflects how the data would be used by supervisors more than how the software was built, and it is unlikely to be solved by interface changes alone. In our reading, staff are more likely to accept being checked if the checks are explained, applied evenly and used to correct processes and not to blame individuals. That point is our interpretation and not a finding of either study.

4.4 Patient and beneficiary experience

Clients in the three focus groups (20 adults in all) said registration was faster, they no longer had to bring old prescription slips, and e-prescriptions carried more complete information [1]. SMS reminders for appointments, medicines and diet were welcomed. They noticed that doctors looked at the screen a lot but did not feel this came between them and the doctor. One participant described a high sugar reading that one doctor forgot to mention and another doctor caught on the e-prescription [1].

The Rajasthan paper has no patient interviews. Its beneficiary data are district counts from Jodhpur: outpatient beneficiaries went from 3,123,123 to 4,139,763 and inpatient beneficiaries from 59,356 to 82,577 between 2015 and 2019, increases of about 33% and 39% [6]. The authors read this as better access, but there is no comparison district, so other causes cannot be excluded. They also report that government spending on medicines through the Jodhpur warehouse rose by 50.29% over 2015 to 2020, and take this as a sign that the public paid less out of pocket, although out-of-pocket spending itself was not measured [6]. The authors say patients' own views of the program still need to be studied [6].

Two things limit what can be taken from the Rajasthan beneficiary figures. First, the counts are for a whole district, so they reflect population change, changes in the free-medicines policy and other factors as well as the software. Second, a rise in outpatient and inpatient counts is a measure of use and not of benefit. Higher use of public facilities is consistent with better access, but it could also reflect, for example, a shift away from private providers for unrelated reasons.

For Chandigarh the patient voice is richer but narrower. Twenty clients from one centre can describe what changed in their own visits, but they cannot speak for the wider population served. The experience reported there concerns registration, reminders and the content of prescriptions [1], while the Rajasthan paper reports nothing at patient level [6]. Neither account measures whether the medicine was available when the patient reached the dispensing counter, although Chandigarh clients described greater medicine availability in general [1].

4.5 Measured outcomes

The Chandigarh paper is qualitative and reports perceptions, not measured outcomes [1]. Staff said reports that once took long could now be produced in 5 to 10 minutes, and auxiliary nurse midwives said a complete record could be found in about 2 minutes. These are quoted estimates from staff, not timed measurements. The Rajasthan paper gives more numbers. The time from demand generation and budget transfer to medicines reaching patients fell from 6–7 months to 3–4 months [6]. The paper also says the system has dealt with chronic shortages and sudden stock-outs, but it gives no stock-out figures. Because records sat in one system and stock in the other, neither study can tell us whether better patient records led to better stocking decisions.

It helps to separate three kinds of number in these studies. The first is a counted value taken from system records, such as the beneficiary counts and the spending total from Rajasthan. The second is a staff estimate, such as 5 to 10 minutes for a report or about 2 minutes to find a record in Chandigarh. The third is an interpretation, such as the claim that higher spending on medicines means lower out-of-pocket payment. All three are useful, but they carry different weight, and only the first could be repeated by another team from the same records.

Fig. 1 plots the Rajasthan values as reported. The fall in the supply cycle from 6–7 months to 3–4 months is the clearest efficiency gain in either study. The paper does not say how much of it came from the software and how much from changes in budgeting or procurement rules, so we read it as an association and not as proof of effect.

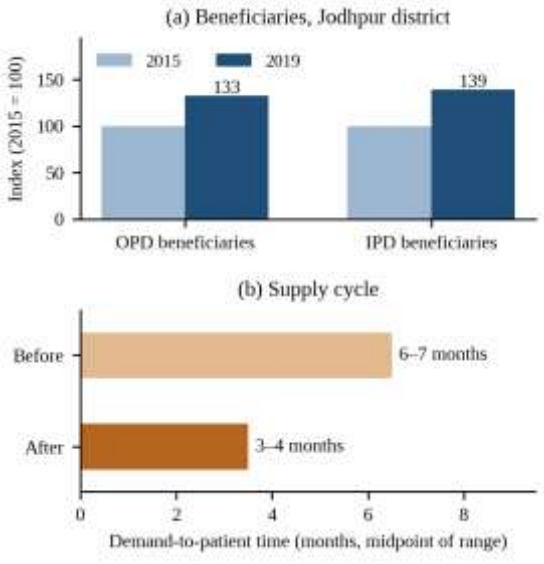


Fig -1: Indicators reported for e-Aushadhi in Jodhpur district [6]

4.6 Remaining barriers

Power and connectivity came up in both. At the Chandigarh centre the inverter gave only four to five hours of back-up, and a multipurpose worker said that after a day without electricity it was hard to enter the records later and account for the medicine dispensed [1]. The Rajasthan authors list lack of electronic infrastructure, power cuts and poor internet among the barriers, and recommend a dedicated fibre network, bar code standardisation, digital signatures and continued training [6]. Staff in Chandigarh also said the software did not cover every diagnosis, with lab reports typed into a comments field, and that searching failed if a medicine name was misspelt [1]. Finally, the lack of clear government direction, and the expectation that new government applications would follow, left some staff unsure about fully adopting the system [1].

The barriers fall into three groups. The first is infrastructure: power back-up, bandwidth and hardware [1], [6]. These lie outside the control of the software team but can be designed around, for example by allowing records to be entered offline. The second is fit and content: rigid fields, incomplete diagnosis lists, brittle search and non-standard coding [1], [6]. These can be improved through iterative design with users. The third is governance: unclear policy direction, parallel reporting demands and uncertain ownership [1]. These cannot be fixed by developers alone and need decisions by the departments that ask for the data. The weight of the three groups matters for planning, because a project that invests only in software leaves two of the three untouched.

4.7 Summary of the evidence

Table 2 gathers the evidence under the six headings. The right-hand column gives our own judgement of how firm the evidence is. It is low to moderate throughout, mainly because both studies are small, uncontrolled and rely heavily on self-report.

Table -2: Evidence by theme for the two systems

Theme	IHIS4PHC (Chandigarh) [1]	e-Aushadhi (Rajasthan) [6]	Strength of evidence
System design	OpenMRS and DHIS2; household "Family Folder"; in-clinic medicine stock	Three tiers; purchase orders from state corporation to district warehouses; demand from facility data	Descriptive in both
Implementation support	Developer and technical assistant on site; staff still relied on the assistant	Annual workshops; peer training; SMS and WhatsApp groups	Qualitative, limited detail
Staff perception	Early resistance eased with use; some felt monitored; fear of dependence on the computer	Most stakeholders satisfied; fibre network and awareness named as needs	Small samples; Rajasthan thin
Patient experience	20 clients: faster registration, fewer old slips, SMS reminders	No patient interviews; district counts only	Moderate for Chandigarh; weak for Rajasthan
Measured outcomes	Staff estimates: reports in 5–10 minutes, record found in about 2 minutes	Cycle 6–7 to 3–4 months; OPD about +33%; IPD about +39%; spending +50.29%	Uncontrolled; no comparison site
Remaining barriers	Power back-up of 4–5 hours; rigid fields; paper registers; unclear policy direction	Power cuts; poor internet; bar code standardisation; training	Consistent across both

Reading across the table, three patterns stand out. First, early friction and the need for sustained support appear in both settings, even though the support models differ. Second, the evidence is thinnest where it matters most for supply: neither study reports stock-out figures, and neither links a clinical record to a stocking decision. Third, the barriers of power, connectivity and standards are shared, which suggests that they belong to the setting and not to a particular piece of software.

5. DISCUSSION

5.1 Two halves of one visit

Read together, the two studies describe two halves of one primary care visit that have been digitised and evaluated separately. IHIS4PHC suggests that a patient-facing record system can shorten follow-up and cut duplicate entry once staff get past the early friction [1]. e-Aushadhi suggests that a supply system with district-level support can shorten the procurement cycle and make stock status visible [6]. Neither shows a patient's diagnosis or a chronic-disease reading feeding into an estimate of how much medicine an area will need next month. The Chandigarh system did track stock inside the clinic and raised alerts when stock ran low, which staff valued, especially for hypertension and diabetes medicines [1], but this stayed within one centre and, as far as the paper reports, was not connected to warehouse or procurement systems. e-Aushadhi works from consumption patterns and budgets [6] and does not hold clinical records. Fig. 2 sets the two systems along a single visit to show where this boundary sits.

This is not unusual. In the 2018 review of mHealth in India, only one of 125 primary studies centred on a supply chain tool and three on electronic health records, and interventions tended to run as stand-alone solutions [2]. A systematic review of the

management literature on digital health found that 82% of its 38 papers set out to design new concepts, while only 11% evaluated existing solutions [18]. The WHO classification of digital health interventions places supply chain management under tools for health system managers, a separate group from tools used by clients and providers [19]. As we read it, this may be one structural reason why the two kinds of system are built and studied by different teams, though none of the reviewed papers makes that claim.

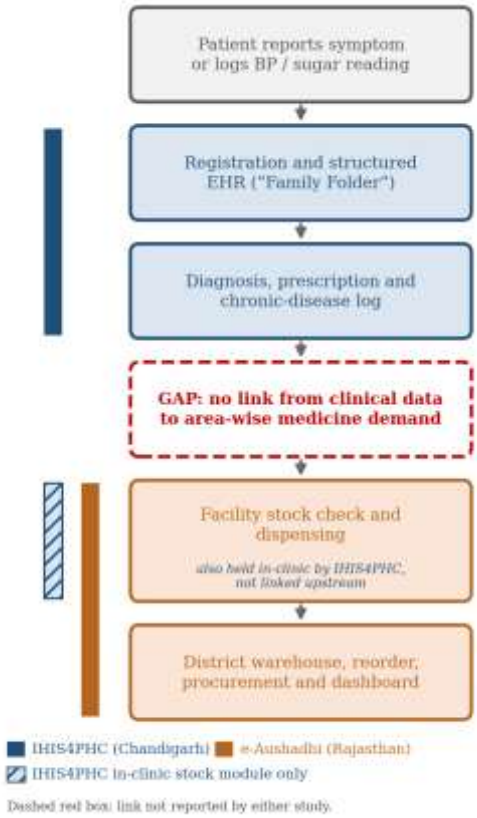


Fig -2: Where IHIS4PHC and e-Aushadhi sit along a single patient visit and medicine supply pipeline

5.2 Adoption as a process

Staff reactions in Chandigarh followed a clear course. Resistance was strongest in the early months, tied to rigid data-entry formats and new accountability, and it eased as staff saw the reporting benefits for themselves [1]. The Rajasthan paper is thinner on this because it rests on a few interviews and does not describe an adoption process in detail [6], so we cannot say the same pattern held there. What the Chandigarh paper does show is that developers and a technical assistant were on site throughout, and the authors link this to how perceptions changed [1].

Taken together, the two studies suggest that adoption is better described as a process than as an event. In Chandigarh the early months were marked by friction, the middle months by growing familiarity, and later months by visible gains in reporting [1]. The NASSS view would add that the process continues after the first year, since systems must be adapted as the organisation changes and some are abandoned once support is withdrawn [16]. Neither study followed its site long enough to say whether the gains held. The Chandigarh interviews took place after six months of use, which is early, and both settings would benefit from follow-up after one or two years.

5.3 Choosing evaluation yardsticks

The studies also used different yardsticks, one behavioural and one a systems-success model, so their findings cannot be scored against each other. A system that covers both clinical and supply functions would probably need to borrow from both: COM-B type constructs for staff adoption [12], and benefit evaluation dimensions such as system quality and net benefit for the supply side [15]. We did not find a single instrument that does both in the material we looked at.

A practical way forward is not to search for a single new framework but to pair the two existing ones. Behavioural constructs capture whether staff can and will use the system, and the success-model dimensions capture whether the system and its information are good and whether they produce net benefit [12], [15], [14]. For a connected system an evaluation could report both sets side by side, for example staff-reported effort and confidence next to measured stock-out days and expiry losses. Constructs from the unified theory of acceptance, such as effort expectancy and facilitating conditions [13], map directly onto the complaints about slow data entry and unreliable power reported in Chandigarh [1], which suggests that behavioural models can be given operational indicators.

5.4 What the gap costs

The gap matters because the information needed to estimate demand largely exists already. Patients with long-term conditions form a predictable group, and a clinic that knows how many of them are on treatment, and when each is due for a refill, already knows much of next month's need. In Chandigarh the system raised alerts when stock ran low, especially for hypertension and diabetes medicines [1], so the clinic knows in a sense what it needs. As far as the paper reports, what is missing is a route by which that knowledge reaches the warehouse.

There is also a technical reason to want clinical data in the estimate. e-Aushadhi works from consumption patterns and budgets [6]. Consumption records what was dispensed, and what can be dispensed is limited by what was in stock. If a medicine ran out, recorded consumption falls to zero and demand is understated. In forecasting terms the observed series is censored by stock-outs [20]. A clinical record that shows how many patients needed the medicine during the stock-out would correct this, and neither system, as reported, supplies it.

A connected system would not fix everything. It would not shorten a procurement lead time, enlarge a budget or correct a supplier's failure to deliver, and the WHO guideline is clear that a stock notification helps only where the supply chain can act on it [10]. Nor would it settle questions about prescribing, since demand estimated from clinical records still reflects what clinicians choose to prescribe. The expected gain is narrower: better information at the point where quantities are decided, so that the quantities are not guessed from consumption alone.

5.5 Workload, fairness and privacy

Connecting systems raises questions that single-purpose systems avoid. Data that flow upward make each centre more visible, and the experience of Chandigarh staff who felt questioned about their records [1] suggests that this may be felt as surveillance. Centres with weak connectivity or frequent power cuts will produce the least data and may therefore look worst, so a connected system should avoid penalising centres for infrastructure outside their control. There is also a workload question. Any new data element asked of a nurse or pharmacist

has to be paid for in time, and the Chandigarh experience of added minutes per consultation [1] shows how quickly such costs are noticed. Finally, because clinical information is involved, the design must settle who may see what, and the legal basis for processing it [9].

5.6 Transferability

Both source studies come from specific places. IHIS4PHC was studied at a single urban centre in Chandigarh, and e-Aushadhi was assessed through the warehouse network of one district in Rajasthan [1], [6]. Rural centres with fewer staff and weaker connectivity may behave differently, and states differ in how they procure medicines and organise primary care. We would therefore expect the mechanisms described here, such as the cost-first, benefit-later course of adoption and the dependence on power and support, to carry over more readily than particular magnitudes such as the fall in the supply cycle from 6–7 to 3–4 months. A pilot of a connected system should deliberately include at least one centre with poor connectivity, because the requirements in Table 3 are most likely to be tested there.

6. DESIGN IMPLICATIONS FOR A CONNECTED SYSTEM

This section moves from review to proposal. None of the ideas below was tested in the studies we reviewed. They are our reading of the barriers the studies report, offered as a starting point for design and evaluation.

6.1 A minimal data flow

Fig. 3 sketches a minimal flow. At the clinic, registration, diagnosis and prescriptions are recorded in the patient record. Instead of sending patient-level data upstream, the system produces a small set of aggregated, de-identified indicators on a regular schedule, for example weekly counts of patients on long-term treatment by medicine class and the quantity dispensed. A demand-estimation layer combines these with stock on hand and reorder rules, and passes suggested quantities to the facility stock ledger and the district warehouse. Stock-out and expiry alerts travel back to the clinic. The design keeps the clinical record local and sends upward only what the warehouse needs.

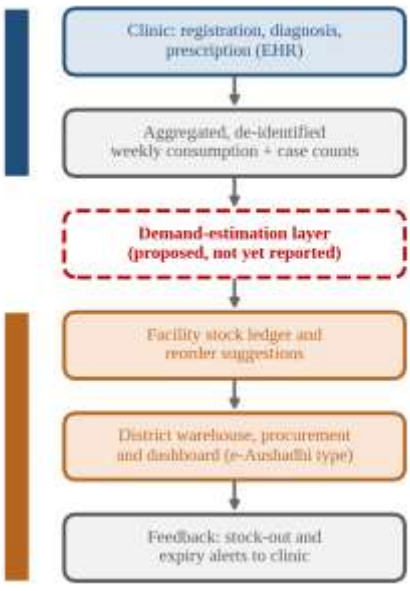


Fig -3: Proposed minimal data flow from clinic to district warehouse and back (conceptual)

6.2 Estimating demand

For chronic conditions the calculation can start simply. As an illustration, if a centre has 400 patients registered on a once-daily antihypertensive tablet, each needs about 30 tablets a month, so the baseline need is about 12,000 tablets before allowing for missed visits, new registrations and a safety buffer. These figures are invented to show the arithmetic and are not data from the studies. The point is that this number comes from the clinical record and not from past dispensing, so it is not distorted by earlier stock-outs.

For acute conditions, which vary with season, time-series methods such as moving averages or exponential smoothing applied to consumption counts can be used [20]. The two approaches can be compared against actual stock-outs over a few months before anything is automated. The aim is a figure that the pharmacist can read and overrule, not an opaque forecast.

6.3 Standards and coding

The reviewed studies report coding problems on both sides: laboratory results typed into a comments field in Chandigarh, and bar code standardisation still needed in Rajasthan [1], [6]. A connected system should use coded fields for diagnoses and medicines, so that the same item means the same thing in the clinic and the warehouse. National EHR standards [7] and the exchange approach of the Ayushman Bharat Digital Mission [8] offer a common starting point, and HL7 FHIR provides a resource model for medication orders, dispensing and supply [21]. We did not assess how far either studied system conforms to these standards.

6.4 Privacy and consent

Because the flow described above uses aggregated counts, most of it would carry little personal risk. The clinic-side record, however, holds personal health data that falls under the Digital Personal Data Protection Act, 2023 [9]. Consent, purpose limitation and secure storage need to be designed in from the start. Small numbers also need care: a centre with only two patients on a rare medicine could identify them through a count, so a minimum reporting threshold should be set.

6.5 Working under power and network limits

Power and connectivity came up in both studies [1], [6]. A connected system therefore has to work offline first, storing entries locally and synchronising when a connection returns, and should send small summaries and not full records. Back-up power for the device used at the pharmacy counter is a modest investment compared with the cost of lost entries, which Chandigarh staff said were hard to reconstruct after a day without electricity [1].

6.6 People and governance

The technology is the smaller part of the task. The Chandigarh staff were uncertain about adopting a system whose long-term status was unclear [1], and nurses kept paper registers because the state still asked for them [1]. A connected system should generate the registers and reports that departments require from the same digital record, so that no one enters the same data twice. It should also be introduced with named local responsibility, a first-line support person during the opening months, and a training route for new joiners, in line with the support patterns seen in both studies [1], [6]. Table 3 turns the barriers found in the review into design requirements.

6.7 An illustrative scenario

To make the flow concrete, consider a patient with hypertension who attends the centre each month. At registration the record is found in the household folder, and the physician renews a once-daily tablet. The renewal adds one to that week's count of patients on that medicine, and no name leaves the centre. When connectivity allows, the weekly summary is sent. The demand layer compares the count and the quantity dispensed with stock on hand, and suggests a reorder if cover falls below an agreed number of weeks. The district warehouse sees the suggestion beside its own stock and expiry data, and decides whether to issue stock or raise a purchase order. If the medicine is short, an alert returns to the centre so that the physician can choose an alternative before the patient reaches the counter. Each step relies on information that one of the two reviewed systems already holds, broadly speaking. What is new is the passing of clinical counts from one to the other. This scenario is an illustration and has not been tested.

Table -3: Design requirements derived from the barriers reported

Design requirement	Evidence in the reviewed studies	Proposed response
Work through power and network loss	Inverter back-up of 4–5 hours [1]; power cuts and poor internet [6]	Offline-first entry with local storage and later synchronisation; small summary uploads
Remove double entry	Paper registers kept alongside the digital record [1]	Generate required registers and reports from the one digital record
Fit data entry to the consultation	Separate drop-downs; rigid fields; search fails on misspelling [1]	Quick-pick for common prescriptions; optional non-essential fields; tolerant search
Make checking feel fair	Staff described questioning as surveillance [1]; audits and complaint desk [6]	Explain data-quality checks; share results with staff; focus on process, not blame
Sustain support after rollout	Reliance on technical assistant [1]; continuous training still needed [6]	Local champion; peer training; tiered helpdesk
Link clinical data to demand	No link in either system [1], [6]	Aggregated, de-identified counts feed a demand-estimation layer
Use coded, shared data standards	Lab reports in comment field [1]; bar code standardisation needed [6]	Coded diagnosis and medicine fields aligned with national standards [7], [8]
Evaluate adoption and supply together	Different yardsticks in the two studies	Paired instrument: staff effort and confidence plus stock-out days and expiry loss

7. RECOMMENDATIONS AND RESEARCH AGENDA

The review points to action for three groups. These are suggestions drawn from the two cases and should be read with the limits set out in Section 8.

7.1 For implementers

Implementers should start small. A pilot in a few centres, limited to a short list of long-term medicines, would allow the data flow in Fig. 3 to be tested without the burden of a full rollout. Baseline measures should be taken before the pilot starts, including stock-out days, expiry losses, time spent on reporting and staff views on workload, because neither reviewed study had a baseline against which later gains could be judged. Support staff should be present in the opening months, and the pilot should be planned so that paper registers can be retired as early as the administration allows.

7.2 For policymakers

Policymakers can help most by removing causes of friction that software cannot fix. Departments that need data should ask for it once and accept it from the digital record. Power back-up and connectivity at the point of care need funding as part of any digital programme. The Chandigarh staff were unsure about adopting a system when the long-term direction was unclear [1], so a clear statement of which application is meant to last would reduce hesitation. The national architecture [8] could also be extended to say how clinical indicators may feed supply planning, within the limits of the data protection law [9].

7.3 For researchers

Researchers can test the idea behind this paper directly. Four questions seem most useful. Does adding clinical counts to demand estimation reduce stock-out days compared with consumption-only estimates? What is the smallest data set that makes the estimate useful? How do staff effort and perception change when a clinic's data are used upstream? What do patients experience at the dispensing counter when stock is available or missing?

Suitable designs include a stepped rollout across centres with later centres acting as comparison, interviews at about six and eighteen months, and indicators such as stock-out days, expiry losses, forecast error (for example mean absolute percentage error) and time spent on reporting. Evaluations should report behavioural and supply outcomes together, as argued in Section 5. Table 4 lists indicators that a pilot could use.

Table -4: Suggested indicators for a pilot evaluation

Indicator	Type	Possible data source
Stock-out days per medicine per month	Supply outcome	Facility stock ledger
Expiry losses (units or value)	Supply outcome	Facility and warehouse records, including expiry tracking [6]
Forecast error against actual need	Supply outcome	Demand layer compared with dispensing records
Time taken to enter a prescription	Workload	Timed sample of consultations or system logs
Time spent on routine reporting	Workload	Staff diary or structured interview

Indicator	Type	Possible data source
Staff effort expectancy and confidence	Adoption	Short survey using items from behavioural models [12], [13]
Medicine available at the counter, as reported by patients	Patient experience	Exit interviews at the dispensing counter
Completeness and timeliness of weekly summary	Data quality	System logs

7.4 Risks to watch

A connected system also brings risks that the reviewed studies do not address and that should be watched in any pilot. Forecasts that are wrong in one direction lead to stock-outs and in the other to expired stock, so suggested quantities should be reviewed by the pharmacist, at least at first. Poor data entered at the clinic will pass straight into the estimate, so data-quality checks need to be built in and explained to staff in the way discussed in Section 5.5. Staff in Chandigarh worried about depending on the computer [1], and a link to the district adds another point of failure, so a manual fallback for ordering should remain available. Finally, indicators used to judge centres can change behaviour, for example by discouraging honest reporting of stock-outs, so the same indicators should be used mainly to direct support and not to rank centres.

8. LIMITATIONS

Two studies are a small base. We did not do a systematic search, so other relevant Indian evaluations may have been missed, and our points about the gap come from comparing what these two papers report, not from a survey of all of India. Both source studies have limits of their own. The Chandigarh study covers one centre during 2017–18 and rests on the views of 20 clients and six staff members interviewed after six months of use [1]. The Rajasthan study draws on one district's dashboard and has no comparison district [6]. Neither measured clinical outcomes. We also relied on the authors' own descriptions of their systems and did not see the software.

The design proposal in Section 6 is untested, and the figures used to illustrate the demand calculation are invented for that purpose. The background in Section 2 draws on policy documents and earlier studies that we did not review systematically, and policy descriptions may have changed since they were written. Finally, our synthesis is shaped by the six headings we chose, and another set of headings might have drawn out other differences.

9. CONCLUSION

Both studies show that digitisation at primary level pays off once staff get past a difficult first few months, with faster reports, less duplicate entry and quicker supply. They also show that patient records and medicine supply have been handled as separate problems. IHIS4PHC kept stock inside the clinic and e-Aushadhi managed it from the district upward, and neither was designed to pass clinical data into demand estimates. Connecting the two sides is therefore still an open task, and any attempt will need to plan early for staff support, reliable power and connectivity, and an evaluation approach that covers both adoption and supply outcomes.

For practice, the message is that a connected system should be planned as a service with support, power, standards and governance, and not as software alone. For research, the most useful next step is a small, well-measured pilot that tests whether clinical counts improve local stock decisions. Until such evidence exists, the case for connecting the two halves rests on the logic of the gap and on the experience of two systems that each did their own job well.

ABBREVIATIONS

Abbreviation	Meaning
COM-B	Capability, Opportunity, Motivation – Behaviour
DHIS2	District Health Information Software 2
EHR	Electronic health record
FHIR	Fast Healthcare Interoperability Resources
HL7	Health Level Seven
IHIS4PHC	Integrated Health Information System for Primary Health Care
IPD / OPD	Inpatient / outpatient department
NASSS	Non-adoption, Abandonment, Scale-up, Spread and Sustainability
OpenMRS	Open Medical Record System
SMS	Short message service
WHO	World Health Organization

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