ORIGINAL ARTICLE

Development of a DDH Care Pathway for India: A Study Methodology to Guide Similar Efforts in Other Countries and for Other Conditions

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Abstract

Purpose In India and other Global South countries, developmental dysplasia of the hip (DDH) is often diagnosed after walking age, leading to more invasive surgeries and long-term disability. DDH care pathways aim to enhance early detection and must be tailored to meet a country's needs and diverse practice settings. We describe a multi-phase methodology for context-specific DDH care pathway development, demonstrating its use in India.

Methods In Phase I, Orthopaedic surgeons, Pediatricians/Neonatologists, and Radiologists in India were surveyed regarding DDH screening. Seven relevant Indian organizations partnered together and assembled a multidisciplinary working group, which then met fortnightly to establish an evidence base and prepare for the subsequent consensus-building phase. During Phase II, panelists participated in a modified Delphi process to reach consensus on a list of DDH screening statements. Phase III applied the statements to develop the care pathway.

Results The Delphi process concluded after a preliminary survey and two Delphi rounds, reaching consensus on 47 statements, which were condensed into 35. The developed care pathway for India features periodic clinical hip examinations integrated with the country's immunization schedule and selective imaging screening, providing flexibility in the timing and modality of imaging.

Discussion/Conclusion In Global South countries, there is a need for DDH care pathways specific to local contexts. Successful care pathway development requires accounting for cultural differences in healthcare and strategies to facilitate engagement and to address country-specific barriers. This methodology was feasible in India and can be applied to other conditions and/or countries wishing to establish care pathways.

Level of Evidence Level III.

Keywords Developmental dysplasia of the hip · Care pathway · Screening · Delphi process

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Introduction

Developmental dysplasia of the hip (DDH) represents a spectrum of hip abnormalities, present at birth or developed during infancy, that ranges from mild dysplasia to hip dislocation [1, 2]. This condition is a common cause of childhood disability and a leading cause of premature hip osteoarthritis requiring total hip replacement [3, 4]. Treatment options largely depend on the age of diagnosis and severity of the dysplasia [5, 6]. Hips diagnosed early (up to six months of age) can usually be managed non-operatively with abduction splinting [2, 6]. However, DDH with advancing severity or age necessitates more invasive surgical management [5, 6], increasing risk for poorer outcomes and complications, requiring further corrective surgeries.

Various screening programmes have been developed to improve the early detection of DDH [7]. While universal clinical examination is widely accepted, controversy exists surrounding the additional use of universal or selective ultrasound imaging for those with DDH risk factors [8–12]. Universal ultrasound screening may lead to unnecessary commitment of resources and over-treatment; however, long-standing universal ultrasound screening programmes in Austria and Germany have demonstrated success at reducing costs and the need for surgery [8, 11–14]. A recent systematic review, similarly, found support for universal ultrasound screening and its cost-effectiveness, though they cite important logistical and financial challenges that would hinder implementation of such a programme in India [15]. Despite ongoing debate over best screening practices, there is no doubt that all screening programmes reduce the late detection of DDH. Thus, especially in countries with limited resources, guidance that is offered must be practical within the region of interest and consider local practices and healthcare cultures to ensure feasibility.

A care pathway is a method used to guide or manage the care of a specific population of patients with a well-defined condition or problem for a well-defined period [16]. They are often developed by a multidisciplinary team, are evidence-based, and are meant to introduce and standardize patient-centered care [17]. Here, we define a DDH care pathway as a decision-making algorithm that guides healthcare providers through the process of screening—from clinical evaluation until referral to an orthopaedic surgeon or return to routine hip surveillance.

In India, the incidence of DDH is estimated to be between 1.0 and 9.2 per 1000 live births [18–20]. Recently, a survey of orthopaedic surgeons practicing in India found that over two-thirds of respondents had performed initial assessments on children with DDH older than one year of age [21]. Hence, a DDH care pathway for India, complemented by additional knowledge translation tools, would aid in the goal of standardizing patient care and enhancing early detection efforts across the country. The aim of this study was to develop a cost- and time-effective methodology to create a DDH Care Pathway for the Indian context, with the goal of detecting the majority of cases before walking age. We describe below the multi-phased approach, the use-case in India, and how it may be applied to guide efforts in other countries and for other conditions.

Methodology and India Use-Case

Overview of the Care Pathway Development Process

The Pediatric Orthopaedic Society of India (POSI) and the Indian Academy of Pediatrics (IAP) led this joint initiative,

with support from international collaborators. A three-phased approach was designed, requiring successful completion of the previous phase to continue into the subsequent phase (Fig. 1). Ethics approval was obtained by the coordinating institution for each phase of the project. Phase I focused on knowledge-building, increasing buy-in, and the enlistment of a working group in preparation for the following phase. In Phase II, panelists participated in a modified Delphi process to reach consensus on a comprehensive list of statements regarding DDH screening. In the final phase, a core writing group assembled the care pathway, which was reviewed by panelists and then endorsed by all participating organizations.

Phase I

Expert Group Formation

Key members from POSI and IAP were enlisted, and partnerships were then formed with the National Neonatology Forum of India (NNFI), Indian Radiological & Imaging Association (IRIA), Indian Federation of Ultrasound in Medicine & Biology (IFUMB), Federation of Obstetric & Gynaecological Societies of India (FOGSI), and Indian Orthopaedic Association (IOA)—all seven organizations representing over 120,000 healthcare providers in India. Each organization nominated representatives from various regions of the country to join the group based on their expertise on DDH and leadership within their respective organizations. The resulting expert group, designated as the DDH India Care Pathway Working Group, consisted of a group of orthopaedic surgeons, pediatricians, neonatologists, gynaecologists, and radiologists, reflecting the range of physician stakeholders relevant to the care of DDH patients in India. In view of travel restrictions imposed by the COVID-19 pandemic in 2020–2021 and the geographical distribution of the group members, meetings were conducted virtually using the Zoom platform (Zoom Video Communications, Inc. 2012, Version 5.0, San Jose, CA, USA). Email and web applications were used to facilitate communication between group members.

Initial Survey of Specialty Groups

Upon forming partnerships, the members of POSI, IAP, NNFI, IRIA, and IFUMB were surveyed to understand the scope of options available to providers in India prior to consensus-building. Surveys were developed in collaboration with international investigators and local experts and asked about DDH resource availability, current screening and referral pathways, attitudes towards care pathways, and other discipline-specific questions. Surveys were
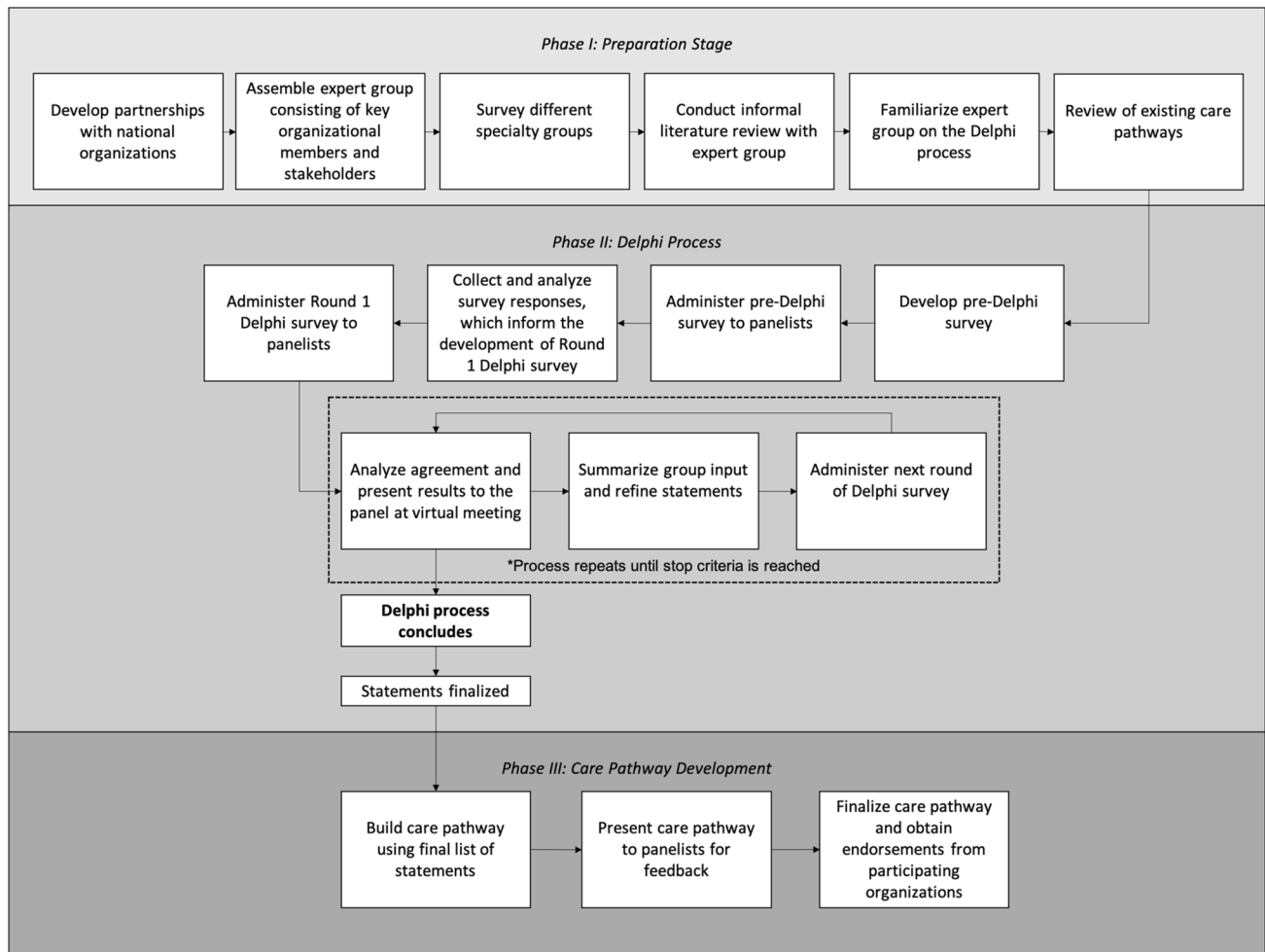
Fig. 1 Flow diagram of the multi-phase process used for care pathway development. Adapted from Salkind NJ, eds. *Encyclopedia of Measurement and Statistics*. Thousand Oaks, CA: Sage Publications, Inc.; 2007: 242. https://doi.org/10.4135/9781412952644

administered using the Research Electronic Data Capture (REDCap) tool, a secure web application designed for building and managing online surveys and databases hosted at the coordinating institution (REDCap. 2004, Version 10.6.25, Vanderbilt University, Nashville, TN, USA) [22, 23]. Preliminary survey findings demonstrated good access to ultrasound and X-ray; however, they suggested potential variability in the quality and reliability of ultrasound reporting, complicating the existing debate on selective versus universal ultrasound screening and necessitating further discussions on care pathway flexibility to account for this variability. The surveys also demonstrated low awareness about DDH among pediatricians/neonatologists, and limited experience with clinical and imaging tools for diagnosis. To improve awareness, infographics outlining the incidence of DDH, risk factors, diagnostic tools, and the importance of early detection and management were developed and circulated to organizational members.

Literature Review

Group members participated in a three-month literature review process through a series of fortnightly meetings, which included scheduled presentations by group members followed by questions and discussion. Presenters synthesized relevant high-quality articles on designated topics, including the incidence of DDH in India, clinical examination, the role of imaging, and comparisons of existing screening programmes. An online repository of comprehensive literature was also created for the group and stored on a cloud-based server for ready reference.

Preparatory Meeting for Consensus-Building

Upon completion of the literature review, the consensus-building phase was introduced. The external facilitator reviewed existing care pathways and explained the upcoming modified Delphi approach, outlining past uses

of the Delphi along with the panelist's role, significance, and extent of their expected commitment during Phase II.

Phase II

Overview of the Delphi Process

The aim of Phase II was to reach consensus on a comprehensive list of statements for the screening of DDH from birth until walking age in India. To achieve this, the Delphi approach, which is a consensus-building method requiring iterative surveys and controlled feedback, was used [24]. The modified Delphi process used in this study employed online rounds of surveys, along with virtual meetings between each round, until a pre-designated stopping point was reached (Fig. 1).

Each Delphi survey consisted of a list of consensus statements regarding key components of DDH screening. Statements were rated on a five-point Likert scale and 80% was set as the threshold of consensus for a given statement ($\geq$ 80% of respondents selecting "agree" or "strongly agree"). Respondents could also select "N/A" (excluding them from the denominator) if they felt that they lacked the expertise to provide a rating. Each consensus statement was followed by an optional comment box for respondents to address concerns, propose changes, ask questions, and/or explain the rationale for their selection.

All surveys were administered using REDCap and distributed by email and WhatsApp messaging platform. Panelists were given 2 weeks to complete each survey—non-respondents were sent reminders throughout the period. Those who were unable to complete the survey in the designated time frame were excluded from the round and any following rounds; however, their survey results from previous round(s) were retained for analysis.

At each virtual meeting, the external facilitator presented the aggregate results and the panelists discussed the statements, focusing on ones that did not reach consensus. Panelists unable to attend the meeting could view a recorded version of the meeting or a slide deck containing the results and summary of the discussion. After each round, statements that reached consensus were incorporated into the final list. Statements were also modified, added, removed, or brought back in the subsequent round based on group input and the discretion of the investigators. A priori, it was determined that the Delphi process would conclude when a) $\geq$ 90% of cumulative items reached consensus or b) after four iterations of the Delphi survey were completed.

Preliminary "pre-Delphi" Survey

The preliminary survey consisted of 32 questions and served as the foundation for the subsequent Delphi survey (Fig. 2). Panelists were asked about their practice characteristics and opinions regarding DDH screening: risk factors, clinical exam, ultrasound, X-ray, and timing of referral. The demographic characteristics of the 29 respondents are summarized in Table 1.

The preliminary survey favored universal clinical screening (69%) with age-dependant clinical tests and selective imaging using either ultrasound (97%) or X-ray (93%). Similar to the specialty group surveys, ultrasound and X-ray were available; however, there was variability in opinion on the age range for ultrasounds and lower age limit for X-rays. However, all respondents agreed that the availability of quality ultrasound reporting and interpretation must be considered when determining imaging modality. The survey also highlighted the need to incorporate trained paramedical personnel as potential users of the care pathway, including auxiliary nurse midwives, accredited social health workers, mobile health teams at the community level, and medical teams at district early intervention centers and district hospitals.

Delphi Round 1

The results of the preliminary survey were used to frame consensus statements for Round 1, which consisted of 37 statements. In total, 28/29 (97%) preliminary respondents completed the survey, with 70% (26/37) of statements reaching consensus, thus necessitating another Delphi round. Following the group meeting, eight new statements were developed, 11 statements that had not been agreed upon were re-worded into 13 statements, and one statement which was previously agreed upon was also re-worded and included (Fig. 2).

Delphi Round 2

Round 2 consisted of 22 statements and was completed by 25/28 (89%) respondents from Round 1. An additional 20 statements reached consensus, for a cumulative 96% (45/47), thus meeting the criteria to conclude the Delphi process (Fig. 2). Another meeting was held to share the results, discuss the two remaining statements that did not reach consensus, and then announce the conclusion of the Delphi process.

Statement Finalization

The two remaining statements were re-distributed along with a rationale/summary of the group discussion. All 25 participants who completed Round 2 responded, with both

Fig. 2 Flow diagram of the consensus-building process for DDH care pathway development in India. N = number of survey respondents
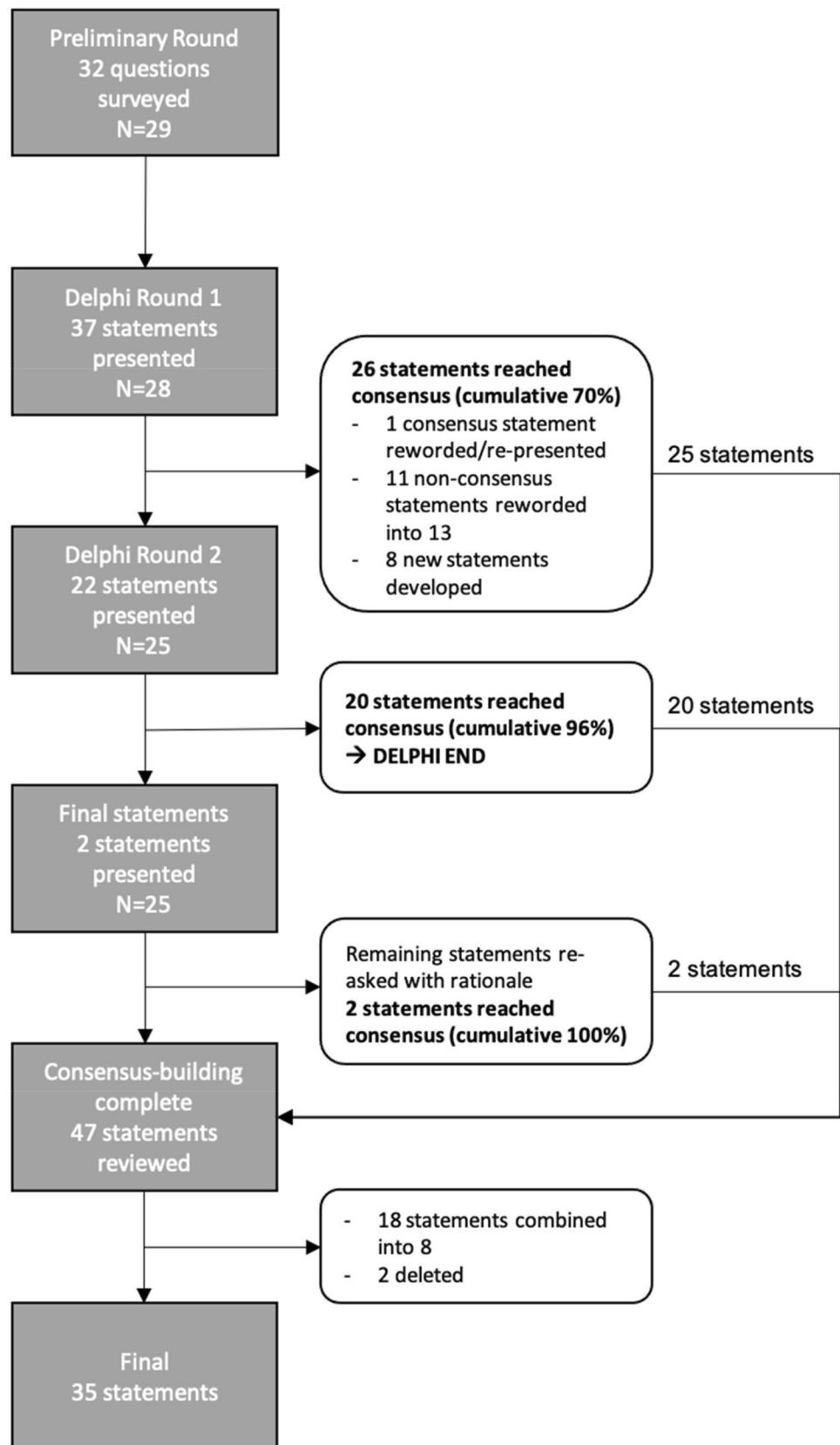
Table 1 Demographic characteristics of the respondents to the preliminary Delphi survey

	N (%)
Clinical occupation	
Orthopaedic surgeon	10 (34.5%)
Pediatrician	10 (34.5%)
Radiologist	4 (13.8%)
Gynaecologist	3 (10.3%)
Neonatologist	2 (6.9%)
Organization representation	
Pediatric Orthopaedic Society of India	9 (31.0%)
Indian Academy of Pediatrics	9 (31.0%)
Indian Radiological and Imaging Association	2 (6.9%)
National Neonatology Forum of India	3 (10.3%)
Indian Federation of Ultrasound in Medicine and Biology	2 (6.9%)
Federation of Obstetric and Gynaecological Societies of India	3 (10.3%)
Indian Orthopaedic Association	1 (3.4%)
Private vs public sector experience	
Private	9 (31.0%)
Public	5 (17.2%)
Both	15 (51.7%)
Solo vs group setting	
Solo	11 (37.9%)
Group	16 (55.2%)
Partnership	1 (3.4%)
Other	1 (3.4%)
Urban vs rural setting	
Urban	28 (96.6%)
Urban and rural	1 (3.4%)

statements reaching consensus. These statements were then incorporated into the list, for a total of 47 consensus statements (Fig. 2).

Three experts (JL, EKS, AA) then reviewed the complete list of statements and divided them into five categories. During this process, 18 statements were simplified into eight statements and two statements were deleted, resulting in a final list of 35 statements (Table 2).

Phase III

In the third phase, a core writing group applied the consensus statements to create the DDH care pathway algorithm for India and a written version. These materials were circulated to the expert panel for revisions. A final meeting was held to review the care pathway before finalization and formal endorsement from all organizations (Fig. 1).

The conclusion of the consensus-building process resulted in a comprehensive algorithm for the screening of

DDH in India, from birth until walking age. The tool reflects the current expert-based consensus among physicians in India and has been designed as a primary guide for use by local healthcare providers. Key features of the care pathway are shown in Table 3.

Discussion

This study demonstrates the successful development and application of a feasible methodology for the creation of a DDH care pathway for India. With a growing population of over 1.3 billion people and the goal of nationwide uptake, the development of a novel care pathway was essential, as established programmes and care pathways in the Global North lack utility in the complex Indian healthcare setting. The care pathway is applicable in the public and private healthcare sectors, and the nation's diverse practice settings and geographic locations, including rural areas which account for approximately 69% of India's population [25]. To our knowledge, no other study has used a Delphi process to develop a care pathway for DDH screening. However, a DDH care pathway has been developed for the St. Luke's Health System in Idaho, USA, considering the state's geographic characteristics and rural population [26]. The pathway provides primary care practitioners and pediatricians with a simple algorithm to manage each case. While the pathway is designed to standardize patient care and enhance the early detection of DDH throughout the health system, it also allows for flexibility, providing alternative pathways for those lacking access to ideal imaging, and ensuring that all children in the health system receive quality DDH screening regardless of their location or life circumstance [26].

In 2019, Kelley et al. used the Delphi method to reach consensus on a set of principles for the management of DDH with a Pavlik harness [27]. Similarly, Roposch et al. (2011) established international consensus on diagnostic criteria for DDH in early infancy using a Delphi process; however, the consensus gained from these studies inform practice and emphasize global as opposed to regional or country-specific guidance [27, 28].

The Delphi method was ideal for this study because of the existing controversy surrounding best practices for DDH screening, necessitating a methodology that integrates evidence in the literature with the best judgment of experts. Additionally, the ability to conduct the process virtually resolved the logistical and financial challenges of facilitating meetings with a large and geographically diverse panel. Our involvement of experts from diverse settings and specialties during consensus-building has been recommended to bring in alternative viewpoints and ensure a wide knowledge base [29, 30]. Obtaining support from leaders and stakeholders from multiple organizations will also help to increase future

Table 2 Final list of 35 consensus statements developed for the DDH India Care Pathway subdivided into five categories

Clinical Exam
1. All babies should be screened for DDH using clinical examination
2. For the purpose of DDH screening, babies should receive a clinical hip examination at birth before the mother and baby are discharged and during well baby checks/vaccination schedule
3. Clinical hip examinations can be performed by trained pediatricians, family doctors, neonatologists, orthopaedic surgeons, obstetricians, radiologists / sonologists and paramedical personnel (e.g. Auxiliary Nurse Midwives (ANM) / Accredited Social Health (ASHA) Workers / Anganwadi Workers (AWW) / Mobile health units / Medical teams at District Early Intervention Centers)
4. 'Routine health supervision' entails regular clinical hip examinations using age-appropriate tests that occur at birth and during vaccination schedules / well-baby checks
5. With regards to DDH screening, the minimum clinical tests for babies <14 weeks of age include Ortolani and Barlow maneuvers
6. With regards to DDH screening, the minimum clinical tests for babies 14 weeks - 6 months of age are limited hip abduction and Galeazzi test (unequal height of knees)
7. With regards to DDH screening, the minimum clinical tests for babies >6 months of age are limited hip abduction, Galeazzi test (unequal height of knees), and sign of limp (if walking)

Ultrasound
1. If quality ultrasound is available, it CAN (not necessarily should) be used as a DDH screening tool any time from birth to 6 months of age if desired
2. A baby with abnormal US findings should immediately be referred to an orthopaedic surgeon

X-ray
1. With regards to radiographs, IHDI and/or Tonnis classification can be used to grade dysplasia if the ossific nucleus is present
2. With regards to radiographs, IHDI classification should be used to grade dysplasia if the ossific nucleus is not present
3. For the purpose of DDH screening, an x-ray (after 14 weeks of age and in the presence of positive clinical exam and/or positive risk factors) should be obtained if quality ultrasound reporting / interpretation is not available in the area of practice
4. If an x-ray is needed, an AP radiograph is the minimum radiograph required for DDH screening
5. For the purpose of DDH screening, the earliest age to obtain an x-ray (if quality ultrasound is unavailable) is 14 weeks of age (to match vaccination / well-baby schedule)
6. A baby with abnormal x-ray findings should immediately be referred to an orthopaedic surgeon

Decision-making
1. Ideally, a baby <6 weeks of age with a positive Barlow exam should wait to obtain an US at 6 weeks of age (if quality ultrasound is available)
2. If a baby with a positive Barlow exam is <6 weeks of age and the healthcare provider believes the child is at risk for loss to follow-up, an US (if quality ultrasound is available) may be conducted at that time
3. A baby <6 weeks of age with a positive Barlow exam and subsequent abnormal imaging findings should be referred to an orthopaedic surgeon
4. A baby <6 weeks of age with a positive Barlow exam, subsequent normal imaging findings and no risk factors present can return to routine health supervision
5. A baby <6 weeks of age with a positive Barlow exam, subsequent normal imaging findings and risk factors present requires follow-up imaging
6. A baby 6 - 14 weeks of age with a positive Barlow test should obtain an ultrasound and should be referred to an orthopaedic surgeon
7. A baby <14 weeks of age with a positive Ortolani test should obtain an ultrasound and should be referred to an orthopaedic surgeon
8. A baby 14 weeks - 6 months of age with limited hip abduction requires further follow-up imaging (ultrasound/x-ray at the discretion of the medical personnel) and should be referred to an orthopaedic surgeon
9. A baby 14 weeks - 6 months of age with a positive Galeazzi test requires further follow-up imaging (ultrasound/x-ray at the discretion of the medical personnel) and should be referred to an orthopaedic surgeon
10. A baby >6 months of age with limited hip abduction should obtain an x-ray and should be referred to an orthopaedic surgeon
11. A baby >6 months of age with a positive Galeazzi test (unequal height of knees) should obtain an x-ray and should be referred to an orthopaedic surgeon
12. A baby of walking age with a sign of limp should obtain an x-ray and should be referred to an orthopaedic surgeon

Risk Factor Screening
1. For babies with a normal clinical exam, the presence of risk factors should be assessed to determine the need for any follow-up
2. For the purpose of DDH screening, risk factors include breech presentation, family history of DDH, improper swaddling practices, and a history of hip instability
3. A baby at any age with normal clinical exam and no risk factors present can return to routine health supervision
4. All babies <6 weeks of age with a normal clinical exam but risk factors present (breech presentation, family history of DDH, improper swaddling practices, and a history of hip instability) should be screened with an US at 6 weeks (if available) or return for an x-ray at 14 weeks
5. All babies 6 - 14 weeks of age with a normal clinical exam but risk factors present should be screened with an US (if quality ultrasound is available) or return for an x-ray at 14 weeks
6. All babies between 14 weeks - 6 months of age with a normal clinical exam but risk factors present should be screened with either an US or x-ray
7. All babies >6 months of age with a normal clinical exam but risk factors present should be screened with an x-ray
8. All babies undergoing risk factor screening who obtain subsequent normal imaging can return to routine health supervision

buy-in and uptake of the care pathway in India. It was also essential that the composition of the expert panel accounted for cultural differences in healthcare. The target users are primarily pediatricians and neonatologists and hence, involving IAP and NNFI alongside POSI was crucial to the success of this project. Considering the variability in the quality and reliability of ultrasound reporting and restrictive access to ultrasound due to the Pre-Conception and Pre-Natal Diagnostic Techniques (PCPNDT) Act, 1994 banning pre-natal sex determination in India, it was also important to involve sonologists and radiologists to provide feedback on the ideal imaging modality for DDH screening. Additionally,

Table 3 Features of the DDH Care Pathway for India

1. A broad based guideline in order to remain applicable to the diversity of India's healthcare settings
2. Developed for use by clinical healthcare providers, especially paediatricians, neonatologists and primary care physicians; however, it can be utilized by a wide cadre of trained healthcare providers who care for children so as to maximize uptake across the country
3. Focus on 'surveillance' rather than 'screening' – emphasizing the concept of periodic physical examinations as part of regular well-baby checks/vaccination visits until the child is of walking age
4. Recommended periodic hip examinations have been aligned with the immunization schedule [at birth, 6 weeks, 10 weeks, 14 weeks, 6 months, 9 months, 12 months, 15 months and 18 months of age] recommended under the Universal Immunization Programme and established under the National Reproductive & Child Health Programme, National Health Mission, Ministry of Health and Family Welfare, Govt. of India (MoHFW, GOI). This programme brings in millions of children per year into well-baby clinics for immunizations from birth until five years of age
5. Screening based on regular clinical examination of the hips at every well-baby check/vaccination visit in addition to selective imaging using ultrasound or x-ray for any baby with abnormal clinical finding(s) and/or risk factor(s) present
6. Age-specific clinical tests for babies <14 weeks of age, 14 weeks – 6 months of age, or >6 months of age
7. Flexibility in the timing of ultrasound for babies <6 weeks of age depending on potential for loss to follow-up
8. Flexibility in the timing and imaging modality for babies <14 weeks of age without access to quality ultrasound
9. Flexibility in the imaging modality for babies between 14 weeks and 6 months of age
10. Referral to Paediatric Orthopaedic / Orthopaedic Surgeon for abnormal clinical and/or imaging findings.

although obstetrician-gynaecologists may not be relevant to the care of DDH patients in many Global North countries, their participation was important in the Indian healthcare setting as a frequent first point of contact with newborns and their families. In addition to serving as potential examiners of newborn hips, obstetrician-gynaecologists are an important resource for families in India, often guiding parents on various aspects of newborn care, such as hip-safe swaddling practices.

Multiple measures were put in place to manage the inherent challenges resulting from group diversity, such as the ability to opt out of responding to Delphi statements. Additionally, the literature review allowed all group members to become sensitized to the literature. The foundational knowledge base developed prior to solicitation of group members' opinions may have contributed to the generally high levels of agreement in the preliminary survey and resulted in fewer Delphi rounds; however, the extent of review included in the methodology is unique to the group and may not always be necessary.

The consideration of facilitators and barriers to development is key to successful care pathway implementation [31]. Phase I allowed the group to establish rapport and ensured preparedness for the Delphi process. The surveys during this phase also identified critical knowledge gaps that will be addressed during implementation, including deficits in pediatricians' and neonatologists' knowledge about hip-safe swaddling, risk factor screening, and various clinical tests. It also became apparent that bringing children in solely for hip examinations would be challenging, resulting in the alignment of the recommended hip examination schedule with the country's immunization schedule (Table 3). An important

consideration for future care pathways will be to leverage existing infrastructure or programs to simplify implementation and maximize uptake. Additionally, while group members in this study were highly motivated, investigators must be wary of declining motivation and implement appropriate strategies to facilitate and maintain engagement.

One limitation of the use-case in India was the lack of representation from nursing associations, parent groups, and physicians practicing in rural areas in the working group. Although the Indian population continues to urbanize, measures must be taken to ensure that babies in rural areas are not overlooked, as their risk for late detection may be greater due to limited access to health resources. However, the Delphi statements and resulting algorithm did address variability in resource accessibility at every step of the care pathway. This included permitting a wide variety of trained physicians and paramedical personnel to perform clinical examinations and providing flexibility in the timing and/or modality of imaging (Table 3). Nurses and physicians with rural experience will also be involved during implementation and future care pathway revisions. Another inherent limitation of the methodology was the lack of true anonymity during consensus-building [32]. This was mitigated by collecting survey responses outside of the meeting time and presenting aggregate results. Additionally, the success of the initiative relies on the presence of a local champion in the country to serve as the Project Lead. This individual must have the experience, expertise, passion, and positional leadership to unify all relevant organizations and motivate group members through all phases to ensure that the project goals are met.

There is an urgent need for action to reduce global inequities in DDH screening. A context-specific DDH care

pathway such as this has the potential to benefit millions of infants born each year in the country and globally. The cost- and time-effective methodology we have described can be used to develop care pathways in other countries and may be particularly useful in regions with limited funds and other resources. Recently, this approach was successfully used to develop a hip surveillance guideline for children with cerebral palsy in India—this methodology can continue to be applied to other conditions with a similarly large burden and controversy regarding best practices.

Conclusion

The late detection of DDH in Global South countries such as India necessitates global health initiatives to combat this. The three-phased methodology outlined in this paper requires a preparatory phase, a consensus-building phase using a modified Delphi approach, and a care pathway development/writing phase. The methodology was successfully used to develop a DDH care pathway in India, demonstrating feasibility given the limited funds available and the nation's diverse health landscape. Other countries can apply this methodology to develop DDH care pathways, or care pathways for other conditions, that are unique to their local context.

Declarations

Conflict of interest Kishore Mulpuri has received research support from Allergan, Pega Medical and Depuy Synthes (Johnson & Johnson). Kevin G. Shea is on the Medical Advisory Board for Sarcio, Inc.

Minnesota (no financial compensation). For the remaining authors none were declared.

References

1. Aronsson, D. D., Goldberg, M. J., Kling, T. F., Jr., & Roy, D. R. (1994). Developmental dysplasia of the hip [published correction appears in Pediatrics 1994 Oct; 94(4 Pt 1):470]. *Pediatrics, 94*(2 Pt 1), 201–208.

2. Guille, J. T., Pizzutillo, P. D., & MacEwen, G. D. (2000). Development dysplasia of the hip from birth to six months. *Journal of American Academy of Orthopaedic Surgeons, 8*(4), 232–242.

3. Clohisy, J. C., Dobson, M. A., Robison, J. F., et al. (2011). Radiographic structural abnormalities associated with premature, natural hip-joint failure. *Journal of Bone and Joint Surgery. American Volume, 93*(Suppl 2), 3–9.

4. Wyles, C. C., Heidenreich, M. J., Jeng, J., Larson, D. R., Trousdale, R. T., & Sierra, R. J. (2017). The John Charnley Award: Redefining the natural history of osteoarthritis in patients with hip dysplasia and impingement. *Clinical Orthopaedics and Related Research, 475*(2), 336–350.

5. Ganger, R., Radler, C., Petje, G., Manner, H. M., Kriegs-Au, G., & Grill, F. (2005). Treatment options for developmental dislocation of the hip after walking age. *Journal of Pediatric Orthopedics. Part B, 14*(3), 139–150.

6. Yang, S., Zusman, N., Lieberman, E., & Goldstein, R. Y. (2019). Developmental dysplasia of the hip. *Pediatrics, 143*(1), e20181147.

7. Kilsdonk, I., Witbreuk, M., & Van Der Woude, H. J. (2021). Ultrasound of the neonatal hip as a screening tool for DDH: How to screen and differences in screening programs between European countries. *Journal of Ultrasonic, 21*(85), e147-153.

8. American Academy of Orthopaedic Surgeons Evidence-Based Clinical Practice Guideline for the Detection and Nonoperative Management of Pediatric Dysplasia of the Hip in Infants Up to Six Months of Age. https://www.aaos.org/globalassets/quality-and-practice-resources/pddh/pediatric-developmental-dysplasia-hip-clinical-practice-guideline-4-23-19.pdf. Published 4 Sep 2014.

9. Holen, K. J., Tegnander, A., Bredland, T., et al. (2002). Universal or selective screening of the neonatal hip using ultrasound? A prospective, randomised trial of 15,529 newborn infants. *Journal of Bone and Joint Surgery. British Volume, 84*(6), 886–890.

10. Rosendahl, K., Markestad, T., & Lie, R. T. (1994). Ultrasound screening for developmental dysplasia of the hip in the neonate: The effect on treatment rate and prevalence of late cases. *Pediatrics, 94*(1), 47–52.

11. Thaler, M., Biedermann, R., Lair, J., Krismer, M., & Landauer, F. (2011). Cost-effectiveness of universal ultrasound screening compared with clinical examination alone in the diagnosis and

treatment of neonatal hip dysplasia in Austria. *Journal of Bone and Joint Surgery. British Volume, 93*(8), 1126–1130.

12. Westacott, D. J., Butler, D., Shears, E., Cooke, S. J., & Gaffey, A. (2018). Universal versus selective ultrasound screening for developmental dysplasia of the hip: A single-centre retrospective cohort study. *Journal of Pediatric Orthopedics. Part B, 27*(5), 387–390.

13. Thallinger, C., Pospischill, R., Ganger, R., Radler, C., Krall, C., & Grill, F. (2014). Long-term results of a nationwide general ultrasound screening system for developmental disorders of the hip: The Austrian hip screening program. *Journal of Children's Orthopaedics, 8*(1), 3–10.

14. von Kries, R., Ihme, N., Oberle, D., et al. (2003). Effect of ultrasound screening on the rate of first operative procedures for developmental hip dysplasia in Germany. *Lancet, 362*(9399), 1883–1887.

15. Pandey, R.A., & Johari, A.N. (2021). Screening of newborns and infants for developmental dysplasia of the hip: A systematic review. Indian Journal of Orthopaedics.

16. De Bleser, L., Depreitere, R., De Waele, K., Vanhaecht, K., Vlayen, J., & Sermeus, W. (2006). Defining pathways. *Journal of Nursing Management, 14*(7), 553–563.

17. Vanhaecht K, Panella M, van Zelm R, Sermeus W. (2010). An overview on the history and concept of care pathways as complex interventions. *International Journal of Care Pathways., 14*(3), 117–123.

18. Gupta, A. K., Kumari, S., Arora, P. L., Kumar, R., Mehtani, A. K., & Sood, L. K. (1992). Hip instability in newborns in an urban community. *National Medical Journal of India, 5*(6), 269–272.

19. Kaushal, V., Kaushal, S. P., & Bhakoo, O. N. (1976). Congenital dysplasia of the hip in northern India. *International Surgery, 61*(1), 29.

20. Singh, M., & Sharma, N. K. (1980). Spectrum of congenital malformations in the newborn. *Indian Journal of Pediatrics, 47*(386), 239–244.

21. Hooper, N., Aroojis, A., Narasimhan, R., et al. (2020). Developmental dysplasia of the Hip: An examination of care practices of orthopaedic surgeons in India. *Indian J Orthop., 55*(1), 158–168.

22. Harris, P. A., Taylor, R., Thielke, R., et al. (2009). Research electronic data capture (REDCap): A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42*, 377–381.

23. Harris, P. A., Taylor, R., Minor, B. L., et al. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics, 95*, 103208.

24. Dalkey, N., & Helmer, O. (1963). An experimental application of the DELPHI method to the use of experts. *Management Science, 9*, 458–467.

25. Registrar General of India. *Census of India 2011: Provisional Population Totals*. https://censusindia.gov.in/2011-prov-results/paper2/data_files/india/paper2_1.pdf. Accessed 27 Jul 2021.

26. Kevin G Shea CTP. Turning a CPG into a care map. 2016. https://www.aaos.org/AAOSNow/2016/Oct/Research/research03/. Accessed 27 Jul 2021.

27. Kelley, S.P., Feeney, M.M., Maddock, C.L., Murnaghan, M.L., & Bradley, C.S. (2019). Expert-Based Consensus on the Principles of Pavlik Harness Management of Developmental Dysplasia of the Hip [published correction appears in JB JS Open Access. 2020 Sep 02;5(3):]. *JB JS Open Access. 4*(4), e0054.

28. Roposch, A., Liu, L. Q., Hefti, F., Clarke, N. M., & Wedge, J. H. (2011). Standardized diagnostic criteria for developmental dysplasia of the hip in early infancy. *Clinical Orthopaedics and Related Research, 469*(12), 3451–3461.

29. Jones, J., & Hunter, D. (1995). Consensus methods for medical and health services research. *BMJ, 311*(7001), 376–380.

30. Rowe G, Wright G. Expert opinions in forecasting: The role of the Delphi Technique. In: *Principles of Forecasting*: A Handbook for Researchers and Practitioners. Kluwer Academic Publishers, Norwell MA, 2001:125–144.

31. Evans-Lacko, S., Jarrett, M., McCrone, P., & Thornicroft, G. (2010). Facilitators and barriers to implementing clinical care pathways. *BMC Health Services Research, 10*, 182.

32. Keeney, S., Hasson, F., & KcKenna, H. P. (2001). A critical review of the Delphi technique as a research methodology for nursing. *International Journal of Nursing Studies, 38*(2), 195–200.