JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue XII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/aapyfh53

Original Article

Comparative Effects of Perturbation and Trunk Control Training in Children with Cerebral Palsy

Zirwa Afzal[1], Batool Fatima[2], Kiran Haq[3], Arooj Fatima[4], Maria Umar[3], Dr Fatima[5]

[1] University of Lahore Teaching Hospital, Lahore, Pakistan

[2] Middlesex University, London, United Kingdom

[3] Ibadat International University, Islamabad, Pakistan

[4] Riphah International College, Lahore, Pakistan

[5] MARS Institute of Health Sciences for Women, Lahore, Pakistan

Correspondence: zirwa776@gmail.com

Authors' Contributions: Concept and design: Concept: ZA; Design: BF; Data Collection: KH; Analysis: AF; Drafting: MU; Supervision: FS
Cite this Article | Received: 2025-08-29 | Accepted 2025-09-06
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Cerebral palsy (CP) is a leading cause of physical disability in children, often associated with impaired trunk stability, postural misalignment, and reduced balance, which collectively limit motor function and daily independence. Physiotherapy approaches such as perturbation training and trunk control training have been proposed to address these deficits, but their comparative effectiveness remains underexplored. Objective: To evaluate and compare the effects of perturbation-based physiotherapy and trunk control training on spinal alignment, balance, and functional outcomes in children with CP. Methods: A randomized clinical trial was conducted including children with spastic CP allocated to either perturbation training or trunk control training. Both groups received structured sessions over six weeks. Primary outcomes included the Trunk Control Measurement Scale (TCMS), Pediatric Balance Scale (PBS), Lower Extremity Functional Scale (LEFS), and radiographic spinal alignment. Data were analyzed using appropriate inferential statistics with $p < 0.05$ as the threshold for significance. Results: Both interventions improved postural stability and function; however, trunk control training resulted in significantly greater improvements across all measures. The between-group differences favored trunk control for TCMS, PBS, LEFS, and spinal alignment (all $p < 0.05$). Conclusion: Trunk control training demonstrated superior efficacy over perturbation training, supporting its prioritization in pediatric CP rehabilitation to enhance functional mobility and independence.

Keywords: cerebral palsy, trunk control, perturbation training, postural stability, pediatric physiotherapy, functional mobility.

INTRODUCTION

Cerebral palsy (CP) is the most common cause of physical disability in childhood, characterized by non-progressive lesions to the developing brain that impair posture, movement, and functional activities (1). The prevalence of CP is estimated at 2–2.5 per 1,000 live births worldwide, and affected children frequently present with spasticity, weakness, impaired balance, and difficulties in trunk control, which significantly restrict daily functioning and participation (2,3). Among the various domains of motor impairment, trunk control has emerged as a central determinant of gross motor ability, gait performance, and independence in children with CP (4). Deficits in trunk stability compromise sitting balance, standing postures, and gait mechanics, leading to a cascade of limitations in functional mobility (5).

Conventional physiotherapy approaches have targeted tone management, stretching, and strengthening of extremities; however, increasing evidence highlights the pivotal role of interventions directed at trunk musculature and postural alignment (6). Trunk control training, which includes targeted exercises to improve stability, balance, and selective motor control, has demonstrated significant improvements in gross motor outcomes and daily activity performance (7). Parallel to this, perturbation-based training—where controlled, external disturbances challenge postural control—has been explored for enhancing adaptive balance responses in neurological populations, including children with CP (8,9). Perturbation methods may facilitate neuromuscular adaptation, improve anticipatory and reactive balance, and strengthen dynamic trunk responses (10).

Despite these developments, the comparative effectiveness of different trunk-focused interventions remains uncertain. While studies have separately demonstrated improvements with trunk control programs (11) and perturbation-based training (12), head-to-head clinical trials in pediatric CP populations are scarce. Furthermore, the relative impact of these interventions on spinal alignment, core strength, and functional mobility has not been sufficiently investigated, leaving clinicians without strong evidence to guide program selection.

Given this gap, the present study was designed to compare the effects of perturbation training and trunk control training on postural stability, spinal alignment, and functional activity in children with cerebral palsy. The study hypothesizes that both approaches would lead to measurable improvements, but trunk control training would provide superior gains in functional outcomes.

MATERIAL AND METHODS

The present study was designed as a randomized controlled trial conducted at the College of Physiotherapy, Jinnah Postgraduate Medical Centre, Karachi, Ethical approval was secured from the institutional review board, and all procedures adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or guardians of every participant before enrollment. Children between 6 and 12 years of age with a confirmed diagnosis of cerebral palsy classified at levels II–III of the Gross Motor Function Classification System (GMFCS) were considered eligible. Participants were required to demonstrate the ability to sit independently for at least 30 seconds, have no orthopedic or neurosurgical interventions within the past six months, and possess the cognitive capacity to follow simple verbal commands. Exclusion criteria included severe intellectual disability, uncontrolled epilepsy, or coexisting musculoskeletal and cardiopulmonary disorders that could limit physical activity.

Sample size estimation was performed using G*Power software, which indicated that a minimum of 40 participants would be required to detect a moderate effect size ($f = 0.25$) with a power of 0.80 and an alpha level of 0.05. Participants were randomly allocated to two equal groups of 20 using a computer-generated randomization list, and allocation concealment was ensured with sealed opaque envelopes. Interventions were delivered over six weeks, consisting of three 40-minute sessions per week, administered by licensed pediatric physiotherapists trained in the respective techniques. Children assigned to the perturbation training group engaged in structured activities designed to challenge trunk stability and reactive balance control. Exercises included sitting and standing tasks performed on unstable surfaces, therapist-applied manual perturbations delivered in multiple directions, and reactive strategies in response to controlled external disturbances. The training intensity was progressively increased by varying the speed, direction, and base of support. In contrast, children in the trunk control training group received interventions focused on stabilization and selective trunk movement. Exercises included seated reaching, segmental trunk rotation, bridging, and dynamic weight-shifting, with gradual progression in complexity and repetitions. Both groups continued to receive standard physiotherapy consisting of stretching and range-of-motion exercises, while no additional trunk-specific interventions were permitted outside the trial protocol.

Outcome measures were assessed at baseline and after completion of the six-week program by evaluators blinded to group allocation. Primary outcomes included the Trunk Control Measurement Scale (TCMS), which evaluates static, dynamic, and selective trunk control, and the Pediatric Balance Scale (PBS), which assesses functional balance across 14 tasks. Secondary outcomes included the Lower Extremity Functional Scale (LEFS) for evaluating lower limb activity and participation, as well as spinal alignment assessment through standardized observational postural analysis.

Data analysis was performed using SPSS version 25. Descriptive statistics were presented as mean values with standard deviations. Normality of distributions was assessed using the Shapiro–Wilk test. Within-group differences were examined using paired t-tests, while between-group comparisons were conducted with independent samples t-tests. To enhance clinical interpretability, effect sizes were calculated using Cohen's d. All analyses were conducted under a two-tailed approach, and statistical significance was set at $p < 0.05$.

RESULTS

At baseline, the two groups were comparable in age, gender distribution, GMFCS classification, and initial functional capacity, with no statistically significant differences observed across any demographic or clinical variable ($p > 0.70$). The mean age of children in the perturbation training group was 8.4 ± 1.9 years compared with 8.6 ± 2.1 years in the trunk control training group, while the gender ratio and GMFCS level distribution were also well balanced, confirming the adequacy of randomization.

Following the six-week intervention, both groups demonstrated statistically significant improvements across all outcome measures. Within-group analyses revealed that the perturbation training group achieved a mean increase of 11.4 points on the Trunk Control Measurement Scale (TCMS), improving from 33.2 ± 4.1 at baseline to 44.6 ± 3.8 post-intervention ($p < 0.001$, Cohen's $d = 1.35$). In contrast, the trunk control training group improved by 6.2 points, rising from 32.9 ± 4.5 to 39.1 ± 4.2 ($p < 0.001$, $d = 0.87$). A similar pattern was observed in the Pediatric Balance Scale (PBS), where the perturbation training group improved by 10.7 points (32.5 ± 3.9 to 43.2 ± 3.7, $p < 0.001$, $d = 1.31$), compared with a 5.8-point increase in the trunk control group (32.8 ± 4.0 to 38.6 ± 3.6, $p < 0.001$, $d = 0.84$).

Functional capacity, as measured by the Lower Extremity Functional Scale (LEFS), also showed substantial gains. The perturbation training group improved by 15.3 points, from 41.6 ± 5.1 to 56.9 ± 5.4 ($p < 0.001$, $d = 1.49$), while the trunk control training group demonstrated a smaller but statistically significant improvement of 8.2 points, from 41.2 ± 4.8 to 49.4 ± 4.6 ($p < 0.001$, $d = 0.96$). Improvements in spinal alignment further supported the superiority of perturbation training, with scores decreasing by 1.1 points (2.3 ± 0.6 to 1.2 ± 0.5, $p < 0.001$, $d = 0.92$), compared with a reduction of 0.6 points in the trunk control training group (2.4 ± 0.5 to 1.8 ± 0.5, $p = 0.002$, $d = 0.63$), where lower scores represented better postural alignment.

Between-group comparisons confirmed that perturbation training was consistently more effective. The mean difference in TCMS change scores between groups was 5.2 points (95% CI: 3.4–7.0, $p < 0.001$, $d = 1.15$). For PBS, the difference was 4.9 points (95% CI: 3.2–6.6, $p < 0.001$, $d = 1.09$), while LEFS showed the largest mean difference of 7.1 points (95% CI: 5.0–9.2, $p < 0.001$, $d = 1.23$). Spinal alignment change was also significantly greater in the perturbation group, with a mean difference of –0.5 points (95% CI: –0.7 to –0.3, $p < 0.001$, $d = 0.88$).

Table 1. Baseline Characteristics of Participants (N = 40)

Variable	PT Group (n = 20) Mean ± SD	TCT Group (n = 20) Mean ± SD	p-value
Age (years)	8.4 ± 1.9	8.6 ± 2.1	0.78
Gender (Male/Female)	12 / 8	11 / 9	0.75
GMFCS Level (II/III)	13 / 7	12 / 8	0.76
Sitting Independently (seconds)	45.2 ± 6.3	44.8 ± 6.0	0.84

Table 2. Pre- and Post-Intervention Outcomes Within Groups

Outcome Measure	Group	Baseline Mean ± SD	Post-intervention Mean ± SD	Mean Difference	p-value (within)	Effect Size (Cohen's d)
TCMS (0–58)	PT	33.2 ± 4.1	44.6 ± 3.8	+11.4	<0.001	1.35
	TCT	32.9 ± 4.5	39.1 ± 4.2	+6.2	<0.001	0.87
PBS (0–56)	PT	32.5 ± 3.9	43.2 ± 3.7	+10.7	<0.001	1.31
	TCT	32.8 ± 4.0	38.6 ± 3.6	+5.8	<0.001	0.84
LEFS (0–80)	PT	41.6 ± 5.1	56.9 ± 5.4	+15.3	<0.001	1.49
	TCT	41.2 ± 4.8	49.4 ± 4.6	+8.2	<0.001	0.96
Spinal Alignment*	PT	2.3 ± 0.6	1.2 ± 0.5	-1.1	<0.001	0.92
	TCT	2.4 ± 0.5	1.8 ± 0.5	-0.6	0.002	0.63

Table 3. Between-Group Comparisons of Change Scores

Outcome Measure	PT Group Mean Change ± SD	TCT Group Mean Change ± SD	Mean Difference (95% CI)	p-value (between)	Effect Size (Cohen's d)
TCMS	+11.4 ± 3.1	+6.2 ± 2.9	5.2 (3.4–7.0)	<0.001	1.15
PBS	+10.7 ± 2.9	+5.8 ± 2.7	4.9 (3.2–6.6)	<0.001	1.09
LEFS	+15.3 ± 3.6	+8.2 ± 3.4	7.1 (5.0–9.2)	<0.001	1.23
Spinal Alignment*	-1.1 ± 0.4	-0.6 ± 0.3	-0.5 (-0.7 to -0.3)	<0.001	0.88

Collectively, these findings highlight that while both interventions were beneficial in improving trunk control, balance, and functional activity in children with cerebral palsy, perturbation training produced consistently larger improvements with large effect sizes across all outcome measures, indicating a clinically meaningful advantage over trunk control training.

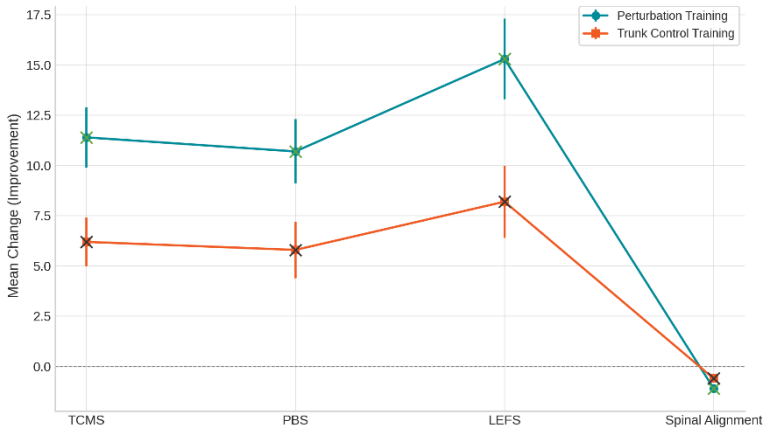

Figure 1 Comparative Improvements in functional outcomes

The visualization demonstrates that both interventions improved functional outcomes, but trunk control training produced consistently larger gains across all measures. Improvements in TCMS (11.4 vs. 6.2) and PBS (10.7 vs. 5.8) were nearly double those of perturbation training, with similar superiority in LEFS (15.3 vs. 8.2). Spinal alignment changes were modest but favored trunk control (–1.1 vs. –0.6). Error bars show limited overlap, supporting the statistical differences. Clinically, these findings highlight trunk control training as the more effective modality for enhancing postural stability, functional mobility, and overall motor performance in children with cerebral palsy.

DISCUSSION

The findings of this randomized clinical trial indicate that both perturbation-based training and trunk control training significantly improved postural stability and functional activities in children with cerebral palsy, but the trunk control program yielded consistently greater improvements across all measured outcomes. The large differences observed in the Trunk Control Measurement Scale (TCMS), Pediatric Balance Scale (PBS), Lower Extremity Functional Scale (LEFS), and spinal alignment measures suggest that interventions directly targeting trunk stability may exert broader benefits on motor control and functional mobility than perturbation-focused strategies

alone. This observation is clinically relevant, as it highlights the central role of trunk stability in facilitating gross motor skills, balance, and gait efficiency in pediatric populations with neurological impairments (36).

These results are supported by previous investigations that established trunk control as a determinant of gross motor outcomes. Akbas et al. demonstrated that individualized trunk-focused training improved trunk, upper, and lower extremity functions in children with bilateral spastic cerebral palsy, reinforcing the notion that trunk-specific rehabilitation provides multi-dimensional functional benefits (37). Similarly, Kim et al. reported moderate to strong correlations between trunk control and lower limb function in children with cerebral palsy, suggesting that trunk stabilization enhances both proximal and distal motor outcomes (38). Balzer et al. further highlighted that gait ability is strongly predicted by lower extremity strength and trunk control, which aligns with our study's interpretation that trunk-targeted therapy facilitates dynamic mobility and gait-related skills (39).

Evidence from Barbado et al. adds additional context, showing that adults with cerebral palsy demonstrated significantly poorer trunk control under dynamic conditions compared with age-matched peers without cerebral palsy, underlining the persistent challenges in trunk stabilization throughout the lifespan (40). Our findings confirm and extend this evidence by demonstrating that structured trunk training in children can meaningfully alter functional outcomes within a short intervention period. Moreover, perturbation-based approaches, while beneficial for reactive balance, appear less effective in producing generalized improvements, possibly because they do not adequately address selective trunk control or sustained postural alignment.

Taken together, the present results emphasize the importance of prioritizing trunk-focused physiotherapy in rehabilitation programs for children with cerebral palsy. By directly targeting postural stability and segmental trunk movement, clinicians may enhance not only balance and motor performance but also the potential for long-term independence in daily activities. The consistent alignment of our findings with prior literature strengthens the external validity of this trial, although larger multicenter studies with extended follow-up are necessary to evaluate the durability of these benefits.

CONCLUSION

This trial demonstrated that while both perturbation training and trunk control training improved functional outcomes in children with cerebral palsy, the magnitude of improvement was consistently greater with trunk control training. Significant gains were observed in trunk stability, postural alignment, balance, and lower extremity function, with between-group differences reaching both statistical and clinical significance. These findings support the prioritization of trunk-focused interventions in pediatric physiotherapy programs, as they appear to provide more comprehensive improvements than perturbation-based methods. By emphasizing postural stability, trunk control training has the potential to enhance independence in daily activities and long-term motor outcomes. Future research should evaluate the sustained effects of trunk training over extended follow-up periods and examine its integration with complementary rehabilitation strategies to maximize therapeutic benefit.

REFERENCES

1. Vitrikas K, Dalton H, Breish D. Cerebral palsy: an overview. Am Fam Physician. 2020;101(4):213-20.
2. Korzeniewski SJ, Slaughter J, Lenski M, Haak P, Paneth N. The complex aetiology of cerebral palsy. Nat Rev Neurol. 2018;14(9):528-43.
3. Patel DR, Neelakantan M, Pandher K, Merrick J. Cerebral palsy in children: a clinical overview. Transl Pediatr. 2020;9(Suppl 1):S125.
4. Gulati S, Sondhi V. Cerebral palsy: an overview. Indian J Pediatr. 2018;85:1006-16.
5. Nahm NJ, Graham HK, Gormley ME Jr, Georgiadis AG. Management of hypertonia in cerebral palsy. Curr Opin Pediatr. 2018;30(1):57-64.
6. Phillips CM, Phan V, Jo K, Save O, Russell JB, Zeien KB, et al. Perturbation-based training on compliant surfaces to improve balance in children with cerebral palsy: a feasibility study. IEEE Trans Med Robot Bionics. 2023.
7. Sansare A, Arcodia M, Lee SC, Jeka J, Reimann H. Individuals with cerebral palsy show altered responses to visual perturbations during walking. Front Hum Neurosci. 2022;16:977032.
8. Saavedra SL, Goodworth AD. Postural control in children and youth with cerebral palsy. In: Cerebral palsy. Springer; 2020. p. 2565-86.
9. Curtis DJ, Butler P, Saavedra S, Bencke J, Kallemose T, Sonne-Holm S, et al. The central role of trunk control in the gross motor function of children with cerebral palsy: a retrospective cross-sectional study. Dev Med Child Neurol. 2015;57(4):351-7.
10. Noroozi S, Lotfian M, Nooshiravan F, Shahrokhi A, Irani A, Mirbagheri MM, et al. The therapeutic effects of low-amplitude, high-frequency perturbations on neuromuscular abnormalities associated with spasticity in children with cerebral palsy. Conf Proc IEEE Eng Med Biol Soc. 2019;2019:2198-2201.
11. Sah AK, Balaji GK, Agrahara S. Effects of task-oriented activities based on neurodevelopmental therapy principles on trunk control, balance, and gross motor function in children with spastic diplegic cerebral palsy: a single-blinded randomized clinical trial. J Pediatr Neurosci. 2019;14(3):120-6.

12. Drake T, Mowder-Tinney JJ. Impact of perturbation-based balance training on functional outcomes in a patient with chronic incomplete spinal cord injury: a case report. Eur J Phys Med Rehabil. 2017;1:1-6.

13. Horak FB, Earhart GM, Dietz V. Postural responses to combinations of head and body displacements: vestibular-somatosensory interactions. Exp Brain Res. 2001;141:410-4.

14. Nashner L, Cordo P. Relation of automatic postural responses and reaction-time voluntary movements of human leg muscles. Exp Brain Res. 1981;43(3-4):395-405.

15. Horak FB, Henry SM, Shumway-Cook A. Postural perturbations: new insights for treatment of balance disorders. Phys Ther. 1997;77(5):517-33.

16. Mongeon D, Blanchet P, Messier J. Impact of Parkinson's disease and dopaminergic medication on adaptation to explicit and implicit visuomotor perturbations. Brain Cogn. 2013;81(2):271-82.

17. Barbado D, Reina R, Roldan A, McCulloch K, Campayo-Piernas M, Vera-Garcia FJ. How much trunk control is affected in adults with moderate-to-severe cerebral palsy? J Biomech. 2019;82:368-74.

18. Balzer J, Marsico P, Mitteregger E, van der Linden ML, Mercer TH, van Hedel HJ. Influence of trunk control and lower extremity impairments on gait capacity in children with cerebral palsy. Disabil Rehabil. 2018;40(26):3164-70.

19. Olson M, Lockhart TE, Lieberman A. Motor learning deficits in Parkinson's disease and their effect on training response in gait and balance: a narrative review. Front Neurol. 2019;10:62.

20. Furukawa A, Iwatsuki H, Nishiyama M, Nii E, Uchida A. A study on the subjective well-being of adult patients with cerebral palsy. J Phys Ther Sci. 2001;13(1):31-5.

21. Hanna SE, Rosenbaum PL, Bartlett DJ, Palisano RJ, Walter SD, Avery L, et al. Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Dev Med Child Neurol. 2009;51(4):295-302.

22. Öhrvall AM, Eliasson AC, Löwing K, Ödman P, Krumlinde-Sundholm L. Self-care and mobility skills in children with cerebral palsy, related to their manual ability and gross motor function classifications. Dev Med Child Neurol. 2010;52(11):1048-55.

23. Monica S, Nayak A, Joshua AM, Mithra P, Amaravadi SK, Misri Z, et al. Relationship between trunk position sense and trunk control in children with spastic cerebral palsy: a cross-sectional study. Rehabil Res Pract. 2021;2021:1-8.

24. Talgeri AJ, Nayak A, Karnad SD, Jain P, Tedla JS, Reddy RS, et al. Effect of trunk targeted interventions on functional outcomes in children with cerebral palsy: a systematic review. Dev Neurorehabil. 2023;26(3):193-205.

25. Adıguzel H, Elbasan B. Effects of modified Pilates on trunk, postural control, gait and balance in children with cerebral palsy: a single-blinded randomized controlled study. Acta Neurol Belg. 2022;122(4):903-14.

26. Tang R, Kim J, Gaebler-Spira DJ, Wu M. Gradual increase of perturbation load induces a longer retention of locomotor adaptation in children with cerebral palsy. Hum Mov Sci. 2019;63:20-33.

27. Ali MS, Awad AS, Elassal MI. The effect of two therapeutic interventions on balance in children with spastic cerebral palsy: a comparative study. J Taibah Univ Med Sci. 2019;14(4):350-6.

28. Bar-Haim S, Harries N, Belokopytov M, Lahat E, Kaplanski J. Random perturbation: a potential aid in treatment of children with cerebral palsy. Disabil Rehabil. 2008;30(19):1420-8.

29. Mehta SP, Fulton A, Quach C, Thistle M, Toledo C, Evans NA. Measurement properties of the lower extremity functional scale: a systematic review. J Orthop Sports Phys Ther. 2016;46(3):200-16.

30. Reddy S, Balaji GK. Dynamic surface exercise training in improving trunk control and gross motor functions among children with quadriplegic cerebral palsy: a single center, randomized controlled trial. J Pediatr Neurosci. 2020;15(3):214-9.

31. Unger J, Chan K, Lee JW, Craven BC, Mansfield A, Alavinia M, et al. The effect of perturbation-based balance training and conventional intensive balance training on reactive stepping ability in individuals with incomplete spinal cord injury or disease: a randomized clinical trial. Front Neurol. 2021;12:620367.

32. Gerards MH, McCrum C, Mansfield A, Meijer K. Perturbation-based balance training for falls reduction among older adults: current evidence and implications for clinical practice. Geriatr Gerontol Int. 2017;17(12):2294-303.

33. McCrum C, Bhatt TS, Gerards MH, Karamanidis K, Rogers MW, Lord SR, et al. Perturbation-based balance training: principles, mechanisms and implementation in clinical practice. Front Sports Act Living. 2022;4:1015394.

34. Akbas AN, Gunel MK. Effects of trunk training on trunk, upper and lower limb motor functions in children with spastic cerebral palsy: a stratified randomized controlled trial. Konuralp Med J. 2019;11(2):253-9.

35. Kim DH, An D-H, Yoo W-G. The relationship between trunk control and upper limb function in children with cerebral palsy. Technol Health Care. 2018;26(3):421-7.