Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Development and Validation of a Conceptual Epidemiological and Economic Model for Predicting Obesity in Low- and Middle-Income Countries: A Systematic Review and Meta-Synthesis–Informed Approach

Francis Fatoye

t.gebrye@mmu.ac.uk

Manchester Metropolitan University https://orcid.org/0000-0001-7976-2013

Chidozie Mbada

Manchester Metropolitan University

Faatihah Niyi-Odumosu

University of the West England

Clara Fatoye

Department of Health Professions, Faculty of Health, Psychology and Social Care, Manchester Metropolitan University

Ushotanefe Useh

North–West University

Zalmai Hakimi

Sobi Ab

Tadesse Gebrye

Manchester Metropolitan University

Article

Keywords: Obesity prediction, economic modelling, epidemiological modelling, low- and middle-income countries (LMICs), systematic review and meta-synthesis

Posted Date: September 29th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10447241/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: There is **NO** conflict of interest to disclose

Abstract

Background

Model-based epidemiologic and economic evaluations are widely accepted as decision-making tools. However, unlike in high income countries, there is little experience of healthcare policies based on evidence of obesity model in low- and middle-income countries (LMICs). The aim of this study was to develop and validate a conceptual epidemiological and economic model to predict obesity in LMICs.

Methods

The study was conducted in two phases consisting of a systematic review to identify relevant evidence, followed by a Delphi panel to achieve expert consensus. The systematic review following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was carried out on MEDLINE, CINHAL and AMED, PubMed, and The Cochrane library and EconLit databases for publications in English from inception to December 2, 2024. Economic evaluation studies where they described an economic model of adult patients with/without obesity in which obesity progression was evaluated were eligible. Title and abstract, full text screening, and data extraction were conducted. Thematic analysis was applied to identify key domains, and this was helpful to develop a conceptual model of obesity in LMICs. The conceptual model was subsequently validated through a Delphi process involving expert consensus to ensure its relevance, completeness, and applicability.

Results

A total of 825 studies were identified, of which 31 met the inclusion criteria in the meta-synthesis. The model type of the included studies was Markov model (n = 23), decision tree (n = 2), discrete event simulation (n = 4), and combination of Markov model and decision tree (n = 2). These studies were published between 1997 to 2024 and were developed based on cohort and patient data. Six health states which include diabetes (n = 19), stoke (n = 14), cardiovascular (n = 14), normal weight (n = 10), overweight (n = 9), and obesity (n = 8) were thematically identified and validated.

Conclusions

This is the first study to develop and validate a conceptual epidemiological and economic model to predict obesity in LMICs. The model can be used to predict the prevalence and the economic burden associated with obesity to inform healthcare decisions to facilitate resource allocation for prevention and management of the condition in LMICs. Therefore, practitioners and policy makers are to be aware that adopting the model may help reduce the prevalence of obesity and the significant economic burden associated with the condition in resource limited settings such as LMICs.

Introduction

Obesity and overweight have become major global public health challenges, with prevalence increasing rapidly in both high-income countries (HICs) and low- and middle-income countries (LMICs) [1]. Globally, an estimated 1.46 billion adults are overweight, including approximately 502 million people living with obesity [2], while an estimated 42 million children under five years of age are overweight [3]. Although obesity was once considered predominantly a problem of HICs, LMICs are now experiencing a rapid rise in prevalence as they undergo epidemiological and nutritional transitions characterized by urbanization, dietary changes, and increasingly sedentary lifestyles [4]. At the same time, many LMICs continue to face the double burden of malnutrition, where undernutrition coexists with increasing rates of overweight and obesity [5]. These trends have contributed to a growing burden of obesity-related noncommunicable diseases (NCDs), including cardiovascular disease, type 2 diabetes, and several cancers, resulting in increasing disability-adjusted life years (DALYs) and substantial pressure on already constrained healthcare systems [1].

The health consequences of obesity are accompanied by considerable economic costs. Obesity increases direct healthcare expenditures through the management of obesity-related diseases and generates substantial indirect costs arising from reduced productivity, absenteeism, disability, and premature mortality [6]. As obesity prevalence continues to rise across LMICs, these health and economic burdens are expected to intensify, underscoring the need for robust evidence to inform prevention strategies, resource allocation, and policy decisions.

Epidemiological and economic simulation models provide valuable tools for understanding disease progression, projecting future obesity trends, and evaluating the long-term impact and cost-effectiveness of interventions. However, most existing obesity models have been developed for HICs and are based on assumptions, risk profiles, and healthcare systems that may not be applicable to LMICs [7]. In addition, relatively few models integrate epidemiological and economic components within a single conceptual framework, and there is limited methodological guidance for developing conceptual models that reflect the unique demographic, socioeconomic, and epidemiological characteristics of LMICs. This lack of context-specific conceptual models limits the ability of policymakers to anticipate the future burden of obesity and evaluate potential interventions in resource-constrained settings.

To address this gap, this study aimed to develop and validate a conceptual epidemiological and economic model for predicting obesity in LMICs using a systematic review and meta-synthesis informed approach. Model development was informed by a systematic review and meta-synthesis, which synthesized evidence on obesity epidemiology, disease progression, risk factors, obesity-related health outcomes, and existing modelling approaches. The evidence generated from the review was used to identify and define the key health states, transitions, and determinants that form the conceptual structure of the model. The proposed model was subsequently subjected to a structured validation process to evaluate its conceptual validity, clinical relevance, and consistency with current evidence and expert understanding of obesity progression in LMICs.

Methods

The study was implemented in two complementary phases. The first phase involved a systematic review to identify the relevant evidence, while the second phase employed a Delphi panel to achieve expert consensus and refine the conceptual model.

Phase 1

Systematic review and thematic analysis.

To identify and define the key health states, transition pathways, and determinants underpinning the conceptual Epidemiological and Economic Model for Predicting Obesity in Low- and Middle-Income Countries (LMICs), a systematic review and meta-synthesis methodology was employed. This approach enabled the comprehensive identification, critical appraisal, and synthesis of existing evidence from the literature to establish the core components of the model.

A comprehensive systematic review was performed following the PRISMA guidelines, as specified by Moher et al. [8]. This approach provided a robust and transparent methodology for identifying, assessing, and synthesising relevant studies. Furthermore, the review was officially registered with PROSPERO, the International Prospective Register of Systematic Reviews, under registration number CRD: 42024506669, ensuring proper oversight and minimising the risk of duplicating existing work.

Search strategy and data sources

The literature search for this systematic review was conducted across multiple databases, including MEDLINE, CINAHL, AMED (The Allied and Complementary Medicine Database), PubMed, The Cochrane Library, and EconLit, encompassing studies published from inception to December 2, 2024. The search terms utilised included a range of combinations such as economic model, Markov model, decision tree, simulation model, obesity, overweight, BMI, cost-effectiveness analysis, cost-utility analysis, economic evaluation, economic impact, and cost analysis. In addition to these databases, hand searches were performed by reviewing the reference lists of included studies. The search terms were cross-referenced with Medical Subject Headings (MeSH) terms to ensure comprehensive coverage. All references were imported into Covidence for screening and management. To minimise bias in the study selection process, the search was independently conducted by two reviewers (TG and CM), with any discrepancies resolved through discussion with a third reviewer (FF).

Inclusion and exclusion

Studies that examined the health and economic consequences of obesity, a primary public health concern that often defines the problem, were included. In line with Briggs et al. [9], simulation models were defined as those integrating an epidemiological model structure with disease cost and health state utility data to conduct economic evaluations of public health interventions. Included studies

demonstrated the progression of obesity and its associated health economic outcomes, such as cardiovascular disease, diabetes, cancers, quality-adjusted life-years (QALYs), disability-adjusted life-years (DALYs), incremental cost-effectiveness ratios (ICERs), life-years gained, and cost assessments. Only peer-reviewed studies published in English were included. Exclusion criteria consisted of studies unrelated to model-based economic evaluations of obesity, as well as conference abstracts, case reports, commentaries, editorials, review articles, and studies lacking sufficient data for analysis.

Study selection

Titles and abstracts as well as full-text articles were screened and assessed by two independent reviewers (TG and CM) based on pre-established inclusion and exclusion criteria. Any discrepancies encountered during the selection process were resolved through consensus, with a third reviewer (FF) consulted when necessary to reach a final decision.

Data extraction

Data extraction was performed to capture key model characteristics, including structure, perspective, health states and disease setting, model type, disease progression, simulation methods, event utility, costs, cycle length, sensitivity analyses, time horizon, Monte Carlo methods, cost-effectiveness drivers, validation procedures, and model limitations. The extraction process was conducted by a single reviewer (TG) and subsequently verified by a second reviewer (CM). Any discrepancies were resolved through discussion or, when necessary, by involving a third reviewer (FF).

Data analysis

A thematic analysis framework, a qualitative research method, was used to identify, analyse, and report patterns or themes within the extracted data [10]. The analysis begins with familiarising oneself with the extracted data, which involves careful reading through the data. Once familiar with the data, the researchers (TG, CM, and FF) move on to systematically labelling/categorising relevant features of the extracted data using Excel sheet. These categories were then collated and grouped into potential themes, with all data relevant to each theme being gathered. After generating themes, the researchers then reviewed them to ensure they accurately represented the data and contribute to the research question.

Phase 2: Conceptual model validation

The conceptual model developed from the systematic review and thematic synthesis underwent preliminary validation using a modified Delphi process. Three experts with complementary expertise in obesity in LMICs, health economic modelling, epidemiology, nursing, and public health, and with experience working in LMIC settings, were invited to review the model. Experts independently assessed the conceptual framework for its relevance, completeness, face validity, and appropriateness for

representing obesity progression and its associated health outcomes in LMICs. Feedback was synthesised and used to refine the model where necessary, with consensus reached on the final conceptual epidemiological and economic model.

Ethics

Ethical approval

was obtained for the Delphi phase of the study from the, Faculty of Health and Education Research Ethics and Governance Committee, Manchester Metropolitan University, United Kingdom (Reference Number: 82367).

Results

Identification and description of studies

A total of 856 records were identified through the database searches. After de-duplication, 775 records remained for title and abstract review. At the title and abstract stage, 53 full-text records were selected to be reviewed. Of these, 31 were found to fulfil the inclusion criteria. Results for each stage of the screening process are presented in Fig. 1.

……Figure 1 about here……

Characteristics of the included studies

The included studies were published between 1997 and 2024. Of the 31 studies included, seven studies were from the USA [11, 12, 13, 14, 15, 16, 17], five were from the Australia [18, 19, 20, 21, 22], four were from UK [23, 24, 25, 26], two were from Spain [27, 28], two were from multiple countries [29, 30], two from Canada [31, 32] and one study from Belgium [33], Colombia [34], Mexico [35], Tunisia [36], Finland [37], Switherland [38], Germany [39], Norway [40], and South Korea [41].

Twenty-four studies [12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 25, 26, 28, 29, 30, 31, 32, 33, 36, 38, 39, 40, 41] were Markov model, three studies [24, 27, 35] were discrete event simulation, two studies [34, 37] were combination of decision tree and Markov models, and two studies [11, 16] were decision tree model.

Identifying and categorising domains

The included studies used various health states to model obesity (see Appendix 1). Nineteen of the included studies were in diabetes, fourteen were in stroke, eleven were cardiovascular, ten were normal weight, nine were overweight, and eight were used obesity. We, then identified these six health states or domains to be used in LMICs. The items that formed these domains are presented in Fig. 2.

……Figure 2 **about here**…….

Developing a conceptual epidemiological and economic model through domain synthesis

Key domains were synthesised to develop the conceptual model (Appendix 1). The six main domains in terms of frequency and impact were diabetes, stroke, cardiovascular, normal weight, overweight, and obesity. A narrative of how these domains interact is presented in Fig. 2.

Preliminary validation of the conceptual model was conducted. The model was reviewed by three key experts with expertise in areas such as obesity in LMICs, economic modelling, epidemiology, nursing, and public health, all with experience in LMIC contexts. The experts confirmed the validity of the conceptual epidemiological and economic model designed to predict obesity in LMICs, as illustrated in Fig. 2.

Discussion

To our knowledge, this is the first study to develop and validate a conceptual epidemiological and economic model specifically for predicting obesity in LMICs. The model was informed by a comprehensive evidence synthesis of 31 studies published between 1997 and 2024, the majority of which employed Markov modelling to simulate obesity progression and its associated health and economic outcomes. The included studies represented diverse geographical regions and healthcare contexts, demonstrating the broad application of simulation models across different policy and health system settings. This diversity strengthens the relevance, credibility, and potential generalisability of the developed conceptual model for informing obesity prevention and management strategies in LMICs. The subsequent expert validation further confirmed that the model appropriately captures the key epidemiological pathways, and economic components required to support future decision-analytic modelling and health policy decision-making in these settings.

The “memoryless” assumption of Markov models [42] implies that the model does not account for individual variations in disease progression, potentially leading to biased estimates, particularly in LMICs where patient demographics and health risks may differ significantly from the general population used in these models. The heterogeneity in patient characteristics, such as age, gender, and socioeconomic status, can influence disease outcomes and complicate the model’s predictions.

Simulation models, particularly dynamic ones, provide invaluable insights into the long-term outcomes of interventions in settings where direct empirical data may be lacking or difficult to obtain [43]. By simulating patient progressions over time, these models help policymakers assess the cost-effectiveness of various interventions, such as lifestyle modifications, pharmacological treatments, and public health policies aimed at obesity prevention [44]. The integration of different health states, such as diabetes, cardiovascular disease, stroke, and obesity, allows for a more comprehensive understanding of how obesity and its comorbidities interact and affect overall health outcomes.

In LMICs, where healthcare resources are limited, simulation models are critical in guiding resource allocation decisions. Policymakers can use these models to predict the impact of interventions on population health and economic outcomes, allowing them to prioritise cost-effective strategies [45]. Additionally, by utilising local health data or adapting global datasets, these models offer flexibility, although the accuracy of the predictions depends heavily on the quality and relevance of the data used [46].

Despite the advantages of simulation models, several challenges remain, especially when applied to LMICs. One of the most prominent issues is the scarcity of accurate, region-specific data [47]. While global datasets are often used in the absence of local data, these datasets may not fully capture the unique characteristics of populations in LMICs, such as diet, physical activity levels, and healthcare access [48]. This limitation can compromise the accuracy of the model's predictions, highlighting the need for more region-specific data collection efforts.

Simulation models have significant potential for influencing policy decisions in LMICs, where limited resources require strategic allocation of healthcare funds. By simulating different intervention scenarios, policymakers can evaluate the potential impact of obesity prevention and management strategies on both health outcomes and costs. Moreover, comparative modelling efforts across different regions and healthcare settings can help identify best practices and areas for improvement.

There are several strengths and limitations of this study that should be considered. A key strength is the rigour in the development of the conceptual predictive model, which was informed by a systematic review conducted in accordance with the PRISMA guidelines [8], followed by expert validation to ensure its relevance and applicability to LMIC settings. The model was developed by synthesising evidence from diverse studies, providing a comprehensive overview of existing epidemiological and economic modelling approaches and model structures. A limitation of this study is that only English-language publications were included, meaning that relevant studies published in other languages may have been missed. Despite this limitation, the review captured a broad range of high-quality evidence across different geographical settings, and the subsequent expert validation strengthens confidence in the conceptual predictive model and its conclusions.

Conclusion

This study is the first to develop and preliminarily validate a conceptual epidemiological and economic model for predicting obesity in LMICs. The study highlights the need for greater transparency in model inputs and reporting of economic evaluations in LMICs. The significance of the findings of the present study is that the model provides a robust framework for predicting the prevalence and economic burden of obesity to inform healthcare policy, resource allocation, and prevention and management strategies in LMICs. As a result, practitioners and policy makers are to be aware that adopting the model may help reduce the prevalence and significant economic burden of obesity in resource limited settings such as LMICs.

Declarations

Author contributions: TG, CM, and FF conceptualised the study. TG and CM carried out the literature search, data extraction and risk of bias assessment with support from FF. TG conducted the narrative synthesis and statistical analyses and wrote the first draft of the manuscript. FF, FN-O, CF, ZH and UU critically reviewed the manuscript. TG, CM, FF, FN-O, CF, ZH and UU approved the manuscript. FF is responsible for the overall content as guarantor.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations

Competing interests: The authors have no competing interests to declare.

Ethical approval: Ethical approval was obtained for the Delphi phase of the study from the, Faculty of Health and Education Research Ethics and Governance Committee, Manchester Metropolitan University, United Kingdom (Reference Number: 82367).

References

1. Ford, N. D., Patel, S. A., & Narayan, K. V. (2017). Obesity in low-and middle-income countries: burden, drivers, and emerging challenges. Annual review of public health, 38(1), 145–164.
2. Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., … Ezzati, M. (2011). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9· 1 million participants. The lancet, 377(9765), 557–567.
3. GBD 2019 Risk Factor Collaborators. “Global Burden of 87 Risk Factors in 204 Countries and Territories, 1990–2019: a systematic analysis for the global burden of disease study 2019”. Lancet. 2020;396:1223–1249.
4. Kassa, M., & Grace, J. (2019). The global burden and perspectives on non-communicable diseases (NCDs) and the prevention, data availability and systems approach of NCDs in low-resource countries. In Public Health in Developing Countries-Challenges and Opportunities. IntechOpen.
5. Horton, S. (2020). Urban/rural differences in stunting and obesity: Trends for low-income and middle-income countries. In Handbook on urban food security in the global south (pp. 79–93). Edward Elgar Publishing.
6. Fatoye, F., Mbada, C., & Gebrye, T. (2024). Clinical and economic burden of obesity in low-and middle-income countries-a systematic review. Value in Health, 27(6, Sup), S82.
7. Xue, H., Slivka, L., Igusa, T., Huang, T. T., & Wang, Y. (2018). Applications of systems modelling in obesity research. Obesity Reviews, 19(9), 1293–1308.

8. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264–9.
9. Briggs, A. D., Wolstenholme, J., Blakely, T., & Scarborough, P. (2016). Choosing an epidemiological model structure for the economic evaluation of non-communicable disease public health interventions. Population health metrics, 14, 1–12.
10. Boyatzis, R. E. (1998). Transforming qualitative information: Thematic analysis and code development. sage.
11. Hampp, C., Hartzema, A. G., & Kauf, T. L. (2008). Cost-utility analysis of rimonabant in the treatment of obesity. Value in Health, 11(3), 389–399.
12. Mital, S., & Nguyen, H. V. (2023). Cost-effectiveness of antiobesity drugs for adolescents with severe obesity. JAMA Network Open, 6(10), e2336400-e2336400.
13. Saumoy, M., Gandhi, D., Buller, S., Patel, S., Schneider, Y., Cote, G., … Sharaiha, R. Z. (2023). Cost-effectiveness of endoscopic, surgical and pharmacological obesity therapies: a microsimulation and threshold analyses. Gut, 72(12), 2250–2259.
14. Hoerger, T. J., Crouse, W. L., Zhuo, X., Gregg, E. W., Albright, A. L., & Zhang, P. (2015). Medicare's intensive behavioral therapy for obesity: an exploratory cost-effectiveness analysis. American Journal of Preventive Medicine, 48(4), 419–425.
15. Paranjape, C. S., Gentry, R. D., & Regan, C. M. (2021). Cost-effectiveness of bariatric surgery prior to posterior lumbar decompression and fusion in an obese population with degenerative spondylolisthesis. Spine, 46(14), 950–957.
16. Shoheiber, O., Biskupiak, J. E., & Nash, D. B. (1997). Estimation of the cost savings resulting from the use of ursodiol for the prevention of gallstones in obese patients undergoing rapid weight reduction. International journal of obesity, 21(11), 1038–1045.
17. Lumbreras, A. G., Tan, M. S., Villa-Zapata, L., Ilham, S., Earl, J. C., & Malone, D. C. (2023). Cost-effectiveness analysis of five anti-obesity medications from a US payer's perspective. Nutrition, Metabolism and Cardiovascular Diseases, 33(6), 1268–1276.
18. Crino, M., Herrera, A. M. M., Ananthapavan, J., Wu, J. H., Neal, B., & Lee, Y. Y. Modelled cost-effectiveness of a package size cap and a kilojoule reduction intervention to reduce energy intake from sugar-sweetened beverages in Australia. Nutrients. 2017; 9 (9).
19. Lee, Y. Y., Veerman, J. L., & Barendregt, J. J. (2013). The cost-effectiveness of laparoscopic adjustable gastric banding in the morbidly obese adult population of Australia. PLoS One, 8(5), e64965.
20. Ananthapavan, J., Tran, H. N. Q., Morley, B., Hart, E., Kennington, K., Stevens-Cutler, J., … Moodie, M. (2022). Cost-effectiveness of LiveLighter®-a mass media public education campaign for obesity prevention. Plos one, 17(9), e0274917.
21. Nguyen, P., Ananthapavan, J., Tan, E. J., Crosland, P., Bowe, S. J., Gao, L., … Moodie, M. (2022). Modelling the potential health and economic benefits of reducing population sitting time in Australia. International Journal of Behavioral Nutrition and Physical Activity, 19(1), 1–12.

22. James, R., Salton, R. I., Byrnes, J. M., & Scuffham, P. A. (2017). Cost-utility analysis for bariatric surgery compared with usual care for the treatment of obesity in Australia. Surgery for Obesity and Related Diseases, 13(12), 2012–2020.
23. Gulliford, M. C., Charlton, J., Prevost, T., Booth, H., Fildes, A., Ashworth, M., … Rudisill, C. (2017). Costs and outcomes of increasing access to bariatric surgery: cohort study and cost-effectiveness analysis using electronic health records. Value in Health, 20(1), 85–92.
24. Miners, A., Harris, J., Felix, L., Murray, E., Michie, S., & Edwards, P. (2012). An economic evaluation of adaptive e-learning devices to promote weight loss via dietary change for people with obesity. BMC health services research, 12, 1–9.
25. Kelly, J., Menon, V., O'Neill, F., Elliot, L., Combe, E., Drinkwater, W., … Hayee, B. (2023). UK cost-effectiveness analysis of endoscopic sleeve gastroplasty versus lifestyle modification alone for adults with class II obesity. International Journal of Obesity, 47(11), 1161–1170.
26. Kindred, M., Shabrina, Z., & Zakiyah, N. (2024). Exploratory Approach to Incorporating Carbon Footprint in Health Technology Assessment (HTA) Modelling: Cost-Effectiveness Analysis of Health Interventions in the United Kingdom. Applied Health Economics and Health Policy, 22(1), 49–60.
27. Castilla, I., Mar, J., Valcárcel-Nazco, C., Arrospide, A., & Ramos-Goñi, J. M. (2014). Cost–utility analysis of gastric bypass for severely obese patients in Spain. Obesity surgery, 24, 2061–2068.
28. Sanchez-Santos, R., Padin, E. M., Adam, D., Borisenko, O., Fernandez, S. E., Dacosta, E. C., … & de la Cruz Vigo, F. (2018). Bariatric surgery versus conservative management for morbidly obese patients in Spain: a cost-effectiveness analysis. Expert Review of Pharmacoeconomics & Outcomes Research, 18(3), 305–314.
29. Konchak C, Prasad K. Incorporating social network effects into cost-effectiveness analysis: a methodological contribution with application to obesity prevention. BMJ Open. 2012;2(6):e001038. doi: 10.1136/bmjopen-2012-001038. PMID: 23117559; PMCID: PMC3533108.
30. Faria, G. R., Preto, J. R., & Costa-Maia, J. (2013). Gastric bypass is a cost-saving procedure: results from a comprehensive Markov model. Obesity surgery, 23, 460–466.
31. Davis, J. A., & Saunders, R. (2020). Comparison of comorbidity treatment and costs associated with bariatric surgery among adults with obesity in Canada. JAMA Network Open, 3(1), e1919545-e1919545.
32. Lester, E. L., Padwal, R. S., Birch, D. W., Sharma, A. M., So, H., Ye, F., & Klarenbach, S. W. (2021). The real-world cost-effectiveness of bariatric surgery for the treatment of severe obesity: a cost–utility analysis. Canadian Medical Association Open Access Journal, 9(2), E673-E679.
33. Borisenko, O., Lukyanov, V., Debergh, I., & Dillemans, B. (2018). Cost-effectiveness analysis of bariatric surgery for morbid obesity in Belgium. Journal of medical economics, 21(4), 365–373.
34. Gil-Rojas, Y., Garzón, A., Lasalvia, P., Hernández, F., Castañeda-Cardona, C., & Rosselli, D. (2019). Cost-effectiveness of bariatric surgery compared with nonsurgical treatment in people with obesity and comorbidity in Colombia. Value in Health Regional Issues, 20, 79–85.

35. Zanela, O. O., Cabra, H. A., Meléndez, G., Anaya, P., & Rupprecht, F. (2012). Economic evaluation of bariatric surgery in Mexico using discrete event simulation. Value in Health Regional Issues, 1(2), 172–179.
36. Galvain, T., Bosut, M. P., Jamous, N., & Ben Mansour, N. (2023). Cost-Effectiveness of Bariatric Surgery in Tunisia. Diabetes, Metabolic Syndrome and Obesity, 935–945.
37. Mäklin, S., Malmivaara, A., Linna, M., Victorzon, M., Koivukangas, V., & Sintonen, H. (2011). Cost–utility of bariatric surgery for morbid obesity in Finland. Journal of British Surgery, 98(10), 1422–1429.
38. Galani, C., Schneider, H., & Rutten, F. F. (2007). Modelling the lifetime costs and health effects of lifestyle intervention in the prevention and treatment of obesity in Switzerland. International Journal of Public Health, 52, 372–382.
39. Borisenko, O., Mann, O., & Duprée, A. (2017). Cost-utility analysis of bariatric surgery compared with conventional medical management in Germany: a decision analytic modeling. BMC surgery, 17, 1–9.
40. Bjørnelv, G. M., Halsteinli, V., Kulseng, B. E., Sonntag, D., & Ødegaard, R. A. (2021). Modeling Obesity in Norway (The MOON Study): a decision-analytic approach—prevalence, costs, and years of life lost. Medical Decision Making, 41(1), 21–36.
41. An, S., Park, H. Y., Oh, S. H., Heo, Y., Park, S., Jeon, S. M., & Kwon, J. W. (2020). Cost-effectiveness of bariatric surgery for people with morbid obesity in South Korea. Obesity Surgery, 30, 256–266.
42. Briggs A, Sculpher M. An introduction to Markov modelling for economic evaluation. Pharmacoeconomics. 1998;13(4):397–409.
43. Sluijs T, Lokkers L, Özsezen S, Veldhuis GA, Wortelboer HM. An innovative approach for decision-making on designing lifestyle programs to reduce type 2 diabetes on dutch population level using dynamic simulations. Frontiers in public health. 2021;9:652694.
44. Ni L, Harris M, Cotterill G, Hoog M, Basarir H, Deger K, van Hest N, Johansson E. P26 Comparison of Cost-Effectiveness Model Outcomes Using Two Individual-Level Simulation Models in Obesity. Value in Health. 2024;27(12):S6-7.
45. Hallett TB, Mangal TD, Tamuri AU, Arinaminpathy N, Cambiano V, Chalkley M, Collins JH, Cooper J, Gillman MS, Giordano M, Graham MM. A healthcare service delivery and epidemiological model for investigating resource allocation for health: the Thanzi La Onse model. medRxiv. 2024 Jan 4:2024–01.
46. Bowman A, Lutze S, Albright J, Blair-Stahn N, Jafari H, Kaur S, Kinuthia C, Mudambi R, Nast P, Pletcher A, Flaxman A. Optimal allocation of antenatal and young child nutrition interventions: an individual-based global burden of disease calibrated microsimulation. BMC Global and Public Health. 2025;3(1):6.
47. Mukonda E, Cleary S, Lesosky M. A review of simulation models for the long-term management of type 2 diabetes in low-and-middle income countries. BMC Health Services Research. 2021;21:1–0.
48. Graneheim, U.H.; Lindgren, B.-M.; Lundman, B. Methodological Challenges in Qualitative Content Analysis: A Discussion Paper. Nurse Educ. Today 2017, 56, 29–34.

Figures

Figure

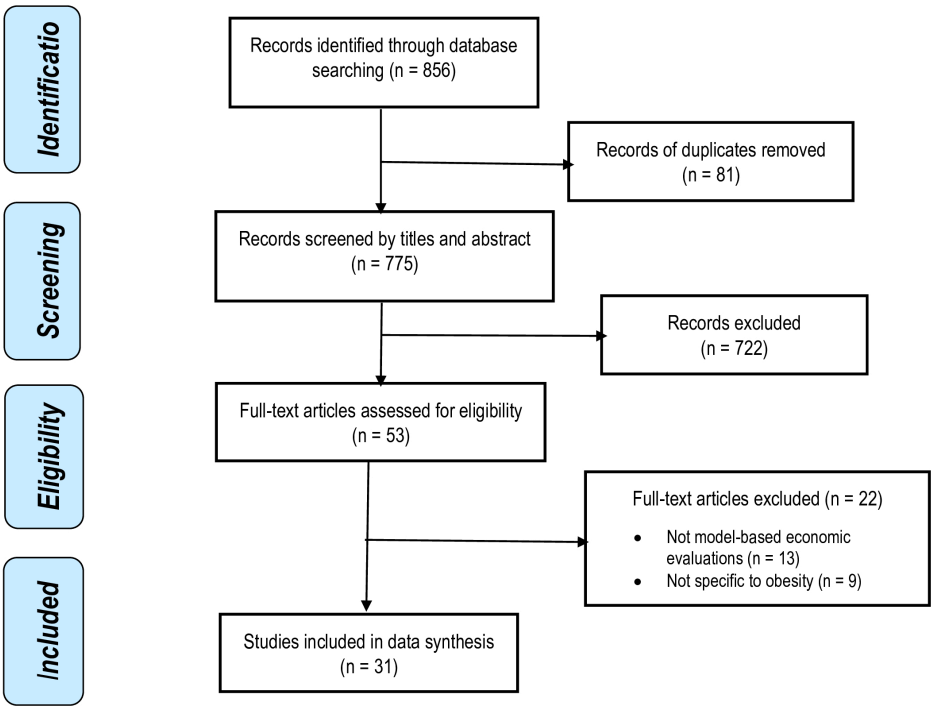

Figure 1. PRISMA flow diagram of publications included and excluded from the review.

Figure 1

PRISMA flow diagram of publications included and excluded from the review.

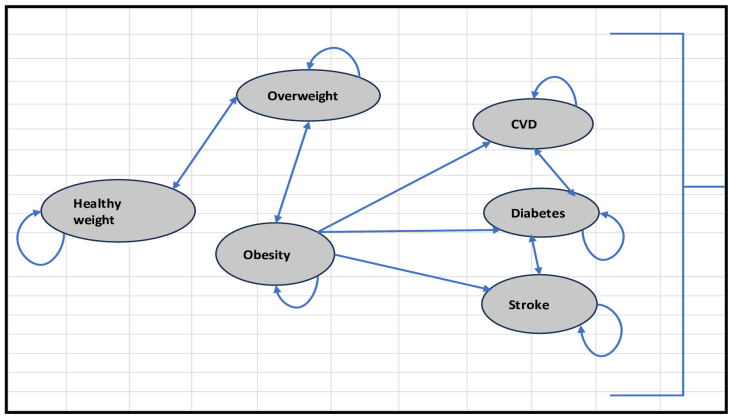

Figure 2: Structure of the Markov model

Figure 2

Structure of the Markov model

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix.doc