

Facilitators and barriers to bicycle helmet use: A qualitative evidence synthesis

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ABSTRACT

Background: Bicycles are environment-friendly and is an effective physical activity intervention to decrease risk of non-communicable diseases. Family physicians and primary care workers play a key role in promoting its usage, including addressing safety concerns through the use of bicycle helmet use. The uptake of bicycle helmets is low in many settings. We aimed to understand facilitators and barriers to bicycle helmet use. **Method:** We searched five major electronic databases, screened references and manually searched conference abstracts for qualitative studies that focused on facilitators and barriers to bicycle helmet use. We critically appraised the studies using the Critical Appraisal Skills Programme (CASP) checklist and used PROGRESS-Plus tool for an equity-focused analysis. We conducted a thematic synthesis for analysis and used GRADE-CERQual to report confidence in findings. **Results:** We included 15 studies from high-income countries. We identified 4 themes: 1. Perceptions on helmet design, its quality and cost together with experiences influencing helmet use (10 studies, low confidence); 2. Perceived risk and benefits of helmet use through a gender lens (10 studies, moderate confidence); 3. Parental strategies influencing children's behavior regarding helmet use (6 studies, moderate confidence); 4. Adoption and enforcement of laws that shape perception and usage of bicycle helmets (8 studies, very low confidence). **Conclusion:** Our study identified facilitators and barriers and can be considered for developing programs and strategies to influence bicycle helmet use, but the confidence in findings is not high. Family physicians and primary care workers should consider these factors when promoting bicycle helmet for injury prevention. There is a need for more qualitative studies in different contexts to develop more robust evidence.

Keywords: Bicycle helmet, bicycling, health behaviour, qualitative, systematic review

Background

Road traffic injuries (RTIs) are a major cause of mortality and morbidity worldwide. Majority of the burden due to RTIs is concentrated in low- and middle-income countries.^[1] Traditionally, the focus of injury prevention is largely on motorized vehicles,

despite a majority of the road users being pedestrians or bicyclists.^[2] Deaths of bicyclists account for 5%, 6% and 4% of all road user deaths in Europe, Western Pacific and Africa, respectively.^[3]

Bicycle is a dominant mode of transport in rural areas^[4] and semi-urban areas. It is gradually becoming popular in cities grappling with pollution, crumbling road infrastructure and the need for people to have a healthy lifestyle.^[5] With public transport being a risk for COVID-19 transmission, bicycle usage is gaining prominence in many countries.^[6] Many governments recognize bicycles as not only a safer mode of transport but also

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a modality to decrease the risk of non-communicable diseases and as a step towards addressing climate change.^[7] Family physicians and primary care workers play a key role in promoting the use of bicycles not only as a physical activity to decrease the risk of non-communicable diseases, but also as a commitment to planetary health. With increasing use of bicycles, the risk of injury in bicycle users is an important area of concern in primary care. Head injuries are common in bicycle-related crashes and account for 47%–69% of hospital admissions.^[8]

Bicycle helmets are known to reduce the risk of head injuries by 63%–88%^[9] and the risk of deaths by up to 50%.^[10,11] While quantitative systematic reviews on the effectiveness of legislative and non-legislative interventions for increasing bicycle helmet use are available,^[12–14] there is no qualitative evidence synthesis to understand facilitators and barriers to bicycle helmet use. Promoting the use of bicycle helmets by family physicians and primary healthcare workers requires an understanding of these factors such that the benefits of bicycle use are not overshadowed by concerns around injury in communities. The current study aimed to fill this gap by synthesizing qualitative studies on perception, attitude, behavior, and experiences around bicycle helmet use.

Methods

Broad approach

We broadly followed the principles and guidance of the Cochrane Qualitative and Implementation Methods Group.^[15–20] The study was reported as per ENTREQ checklist.^[21] The checklist is presented in supplementary appendix 1.

Protocol registration

The review protocol was registered prospectively in and is available on the Open Science Forum (<https://osf.io/8e93d/>). A summary is provided here.

Ethics

The study is a synthesis of evidence from published papers and does not involve any human or animal participants and hence did not require any ethics approval.

Theoretical approach

We approached this from a critical realism standpoint with a pragmatic lens^[21] for the review.

Eligibility criteria for included studies

We included studies which met the following inclusion criteria:

- **Type of studies:** Primary studies that used valid, qualitative approaches for both data collection and data analysis. We included mixed methods studies only when both the methods and results for the qualitative component were reported separately.
- **Participants:** Participants included current and/or potential bicycle helmet users, or stakeholders involved in formulating

policies, programs or implementing bicycle helmet programs, irrespective of any other characteristics.

- **Types of phenomena of interest:** Perceptions, attitudes and experiences of bicycle helmet use and/or non-use or improper use.
- **Restrictions:** Irrespective of setting, language, geography, time of publication and publication status.

Data sources

We searched in five electronic databases (Medline, Embase, Global Health, Australian Transport Index, and SafetyLit). The search strategies which were used are presented in Supplementary Appendix 2. We also manually searched through the reference lists of included studies and the abstract book of the World Conference on Injury Prevention and Safety Promotion (2010–2020).

Studies screening method

Duplicates were removed from records retrieved through electronic database search and screened initially based on title and/or abstract in the first stage, followed by the full text by two reviewers independently. Disagreements, if any, were resolved by consensus with third author. Screening of reference lists of included studies and manual search was conducted by one author initially with full text assessment being conducted by another reviewer.

Data extraction

We extracted data by modifying a pre-existing template used for qualitative evidence synthesis on child seat restraint.^[22]

Appraisal of quality of included studies

We appraised the quality of the included studies by using the Critical Appraisal Skills Programme (CASP) quality assessment tool for qualitative studies.^[23] It has been used in several other qualitative evidence syntheses.^[17,22,24,25]

Synthesis methodology

We used thematic synthesis as defined by Thomas and Harden in 2008 for the purpose of qualitative evidence syntheses.^[26] We decided on the thematic synthesis as the analytical approach of choice, guided by the RETREAT framework^[27].

We used the PROGRESS-Plus framework^[28] to enable understanding of consideration of equity issues in individual qualitative studies. We previously used a similar approach in qualitative evidence synthesis on facilitators and barriers for child seat restraints.^[22]

Assessing confidence in the findings of the qualitative evidence synthesis

Two authors used the GRADE-CERQual^[29] (Confidence in the Evidence from Reviews of Qualitative research) approach to evaluate the confidence in review findings.

GRADE-CERQual approach is based on four domains to adjudicate confidence in review findings. It is divided into four categories (high, moderate, low, very low) wherein a “high confidence” implies that it is highly likely that the review finding is a reasonable representation of the phenomenon of interest and a “very low confidence” implies lack of clarity on the reasonable representation of the review findings. The four domains are:

1. Methodological limitation of the included studies^[30]
2. Coherence of the review findings^[31]
3. Adequacy of the data contributing to review findings^[32]
4. Relevance of the included studies with the review question^[33]

Differences in protocol and the full qualitative evidence synthesis

We intended to do a subgroup analysis, but this was not possible due to the sparse amount of data available: All studies were from high-income countries, involved parents and caregivers as participants.

Results

Results of the search

We identified 195 records in the electronic database search and from other sources to finally include 15 articles which met the eligibility criteria. The reasons for exclusion at full-text stage are listed in Appendix 3. The PRISMA flowchart is shown in Figure 1.

Characteristics of the included studies

Characteristics of the included studies are summarized in Table 1. The different types of studies included were as follows:

- Focus group discussions only^[34–40]
- In-depth interviews only^[41–43]
- Both focus groups and in-depth interviews^[44,45]
- Mixed-method design^[46]
- Focus group and observation^[47]
- Interview and art project artefacts^[48]

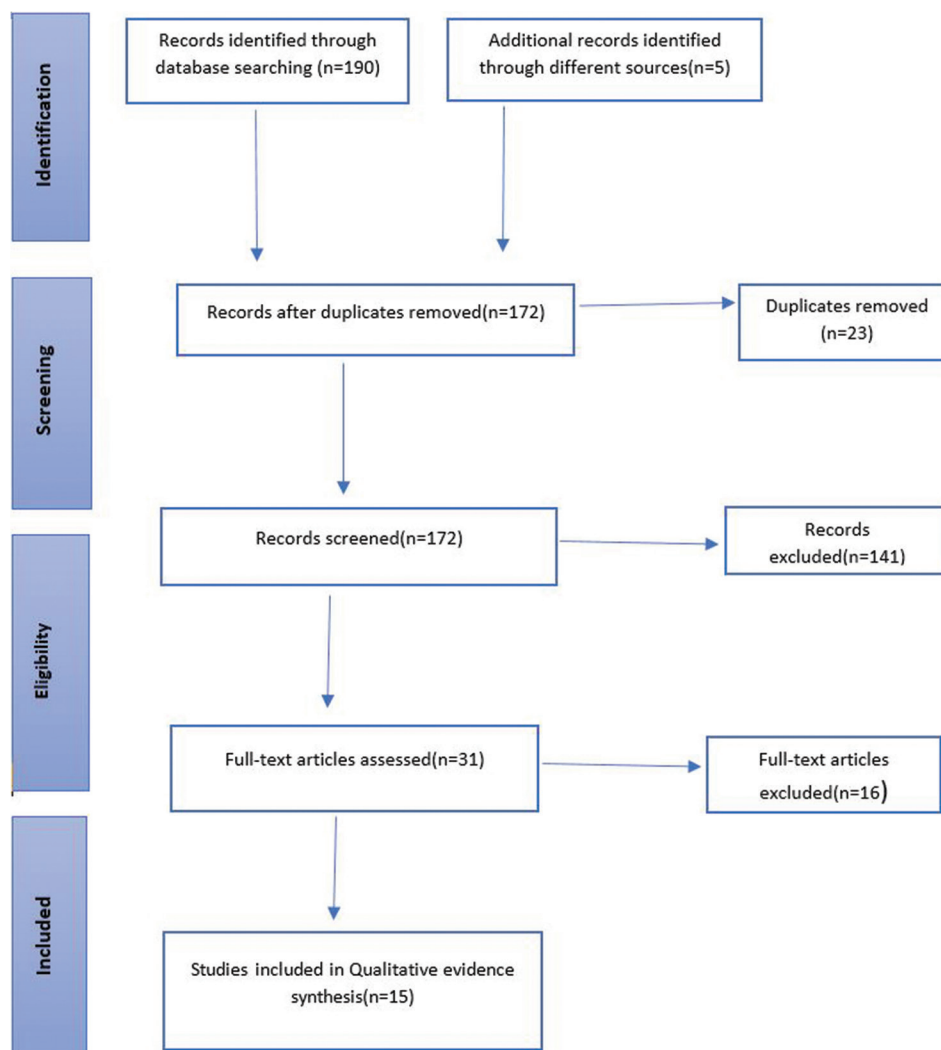


Figure 1: PRISMA flowchart showing inclusion of studies

Table 1: Characteristics of included studies

Study (country)	Type of participants	Study setting	Method of data collection	Method of data analysis
Howland, 1989 (USA)	Children aged 10-14 years (n=42)	Public and private elementary schools	Focus group discussion	Content analysis
Kakefuda, 2015 (USA)	Stakeholder related to bicycle helmet use with age 40 of years or older (n=85)	Fort Collins, Colorado	Semi-structured in-depth interview	The study used a semi-qualitative approach for analysis
Loubeau, 1999 (USA)	Children aged 12-13 years (n=31)	Public middle school and private parochial school	Focus group discussion	Content analysis
Garcia, 2016 (Spain)	Students aged 12-16 years (n=16)	Secondary school, Valencia	Focus group discussion	Content analysis (thematic)
Pierce 2013 (USA)	Children between the ages of 5 and 7 (n=17)	Urban elementary school	Semi-structured in-depth interview	Content analysis
Robertson, 2014 (Canada)	Parents whose average age was 33.1 and had children under the age of 12 (n=62)	Rural communities, Saskatchewan	Focus group discussion	Thematic analysis
Ryan, 2019 (USA)	Children aged 8-11 years and 12-15 years (n=11)	Primary care clinic, urban pediatric hospital	Focus group discussion	Thematic analysis
Stevenson, 1992 (Australia)	Students 7-14 years of age for observation (n=397) and for FGD (n=50)	Primary and high school	Observation and focus group discussion and semi-structured, in-depth interview	Thematic analysis
Halliday, 1996 (England)	Helmet wearers and non-wearers between 9 and 40 years of age (n=84)	Hounslow and more rural locality	Focus group discussion	Thematic analysis
Johnson 2014 (Australia)	Regular cycle commuter aged 25-64 years (n=36)	To and from work location	Semi-structured in-depth interview	Thematic analysis
Nolen, 2010 (Sweden)	Bicycle Helmet Law Coordinating Committee members; age was not specified (n=8)	Not mentioned	Semi-structured, in-depth interview and documents	Phenomenographic approach
Martin 2016 (USA)	Member and non-member of local bike sharing system (n=16); industrial expert interview (n=11); age was not specified	San Francisco, San Jose, California	Focus group discussion and semi-structured interview.	The broader theme was divided into five questions that addressed the roles of stakeholders. FGDs and interviews were not analyzed rigorously.
Hendrickson, 1997 (USA)	Parents (n=34) having school-aged children 6-14 years old; age of the parents was not specified	Urban area or adjacent to urban area, metro area, workstation	Semi-structured, in-depth interview	Thematic analysis
Piotrowski 2020 (Canada)	Parents (n=144) who fulfil the following criteria: a) must be 18 years of age or older, b) must have at least one child between the ages of 4 and 13 years, who was willing to participate, and c) must speak English fluently	Wide variety of community	Focus group discussion	Thematic analysis
Caroline C. Piotrowski, 2020 (Canada)	Children in the age group of 4-13 years (n=76)	Community	Focus group discussion and semi-structured in-depth interview	Thematic analysis

In majority of the studies, the participants were children or adolescent teenagers,^[34–36,38,39,41,47,48] and in three studies, they were parents.^[37,40,42] Two studies had bicycle helmet coordinating committee members, public safety officers, elected officials, bicycle retailers, parent–teacher organization members^[43,44] as participants, and one had bike sharing system members and car drivers.^[45] All included studies were conducted in high-income countries. Studies were conducted in schools^[34,36,46,47,48] or in the community,^[35,37–42,44,45] and one study didn't report the study setting.^[43]

Equity reporting

Only three studies were from rural and semi-urban areas.^[35,37,42] No study aimed to understand the effect of religious and cultural beliefs on helmet use. Seven studies reported on education of the participants,^[34–36,41,44,46,47] but none tried to understand how it affected

helmet use. Socioeconomic status was reported in three studies.^[35,41,47] Only one study reported on disability as a personal characteristic of the participant but did not have any further information.^[35] Equity characteristics are shown in a tabular format in Appendix 4.

Methodological Quality of included studies

The methodological quality of the studies is summarized in Figure 2. None of the studies reported on reflexivity and data saturation; three studies mentioned about data triangulation;^[39,40,48] four studies did not use rigorous analytical methods^[35,45,46,47]

Thematic synthesis findings

Our synthesis led to four themes, which are described subsequently. The GRADE-CERQual evidence profile is presented in Table 2.

Study/CASP	Was there a clear statement of the research?	Is a qualitative methodology appropriate?	Was the research design appropriate to address the aims of the research?	Was the recruitment strategy appropriate to the aims of the research?	Was the data collected in a way that addressed the research issue?	Has the relationship between researcher and participants been adequately considered?	Have ethical issues been taken into consideration?	Was the data analysis sufficiently rigorous?	Is there a clear statement of findings?
1. Howland 1989	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Can't tell	Yes
2. Kakefuda 2015	Yes	Yes	Yes	Yes	Yes	No	Yes	Can't tell	Yes
3. Loubeau 1999	Yes	Yes	Yes	No	Yes	Can't tell	No	Can't tell	Yes
4. Garcia 2016	Yes	Yes	No	No	Yes	No	Yes	No	Yes
5. Pierce 2013	Yes	Yes	Yes	Can't tell	Yes	Can't tell	Can't tell	Yes	Yes
6. Robertson 2014	Yes	Yes	Yes	Yes	Yes	No	Can't tell	Can't tell	Yes
7. Ryan 2019	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	No
8. Stevenson 1992	Yes	Yes	Yes	Can't tell	Yes	No	No	No	Yes
9. Halliday 1996	Yes	Yes	Yes	Can't tell	Yes	No	No	No	Yes
10. Johnson 2014	Yes	Yes	Yes	Yes	Yes	No	Yes	Can't tell	Yes
11. Nolen 2010	Yes	Yes	Yes	Can't tell	Yes	No	No	Can't tell	Yes
12. Martin 2016	Can't tell	Can't tell	Can't tell	No	Yes	No	No	No	Yes
13. Hendrickson 1997	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	Yes
14. Piotrowski 2020a	Yes	Can't tell	Can't tell	Yes	Yes	No	Yes	Yes	Yes
15. Piotrowski 2020b	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Figure 2: Methodological quality of include studies using CASP tool

Perceptions on helmet design, its quality and cost together with experiences influenced helmet use (10 studies, low confidence)

Bicycle users often did not want to wear helmets in spite of acknowledging the safety benefits of helmet use; they had concerns about the helmet design, its quality and cost,^[34–37,39,40,46,48] discomfort due to weather conditions,^[35,36,40,48] restricted vision, poor fitting and a feeling of the chin being hurt due to the strap.^[35,39,40,47]

Many studies reported suggestions on bicycle helmet design: better ventilation, all-weather comfort, and lighter weight being the most common suggestions.^[35,36,48] Three studies reported cost as a deterrent factor for not using bicycle helmets.^[35,37,40] Parents reported the need for purchasing different types helmets for different sporting activities (like cycling, hockey, baseball, quad) as a key inconvenience.^[35,37] In one study, participants linked the cost of a helmet with the degree of protection offered by it. Most expensive helmets were thought to be more protective than a regular one.^[35] Participants expressed that provisions for free or subsidized helmets would encourage helmet use.^[35,37,45]

Non-availability of appropriately sized helmets in the market for all ages was also reported as a limiting factor.^[35,37,40,48] One study reported that the lack of provision of exchanging bicycle helmets when children outgrew them or the helmet became old

or damaged^[35] was a problem. Some participants expressed that if someone was using a helmet, it signified that that person was aware of the dangers of being injured. Even non-wearers had the same view, but they weighed up the factors like risk of injuries, out-of-pocket expenditures (OOPs) due to hospitalization, level of protection provided and then judged whether to use it or not.^[34,35]

Participants of many studies mentioned that having experience of an injury increased the probability of using a helmet, but it had a temporary effect only.^[35–37,40] Parents were less likely to wear helmets in a familiar environment which was described as a short trip, neighbourhood or locality and assessed the risk based on the type of journey, road infrastructure, traffic on the road, speed, children and their own riding experience.^[37,40] Few participants expressed that they would prefer alternative options like bicycle path rather than using a helmet.^[35,48] Here, perceived risk acted as a triggering factor and if it can be addressed in the right way, then it can enable helmet use.

Perceived risk and benefits of helmet use through a gendered lens (9 studies, moderate confidence)

In most studies, participants were aware of the risks of not wearing a helmet.^[34,35,37,39–41] Girls had a more positive attitude towards helmet use than men.^[35] Women and girls were least bothered about helmet design or colour as they considered

Table 2: GRADE-CERQual Summary of Findings Table

Summary of review findings	Assessment of methodological limitation	Assessment of the relevant research question	Assessment of coherence of the data	Assessment of the adequacy of data	Overall CERQual assessment of confidence	Explanation of judgement
Perceptions on helmet design, its quality and cost together with experiences influenced helmet use	Serious methodological limitation (1 study with moderate concern and 1 with no concern, 8 studies with serious concern, not mentioned anything about research reflexivity, sampling strategy, concern about ethical issue and data analysis process)	Minor concern (Except one study, all 9 studies focused on bicycle helmet design, cost; conducted in semi-rural, rural, affluent urban city area and HICs of 3 different continents)	Minor concern (Minor concern about fit between primary data and review findings; Most of the participants reported about design, cost and availability was a barrier)	No concern (10 studies all together gave moderately rich data)	Low confidence	10 studies supported this finding. Major concern about the methodological limitation and Minor concern about relevance and coherence.
Perceived risk and benefits of helmet use through a gendered lens	Moderate methodological limitation (2 studies with no concern, 2 studies with moderate concern, 6 studies with serious concern; not mentioned anything about research reflexivity, concern about ethical issue and data analysis process)	Minor concern (Except one study, all 9 studies focused on bicycle helmet; conducted in semi-rural, rural, affluent urban city area and HICs of 3 different continents)	No concern (review findings well supported by underlying studies)	No concern (10 studies all together gave moderately rich data)	Moderate confidence	10 studies supported this finding. Data were from studies with moderate methodological limitations; minor concerns about relevance, no concerns about coherence and adequacy
Parental strategies influenced children's helmet use behavior	Serious methodological limitation (3 studies with no concern and minor concern respectively, and other 3 studies with serious concern; not mentioned anything about research reflexivity, sampling strategy, concern about ethical issue and data analysis process)	Minor concern (all 6 studies focused on parental strategies; conducted in affluent semi-urban and rural areas and HICs of 2 continents)	No concern (review findings well supported by underlying studies)	No Concern (studies all together offered relatively rich data)	Moderate confidence	6 studies supported to this finding. Data were from studies with serious methodological limitations. Minor concerns about relevance and No concerns about coherence and adequacy.
Adoption and enforcement of laws shapes perception and usage of bicycle helmets	Serious methodological limitation (1 study with no concern, 2 studies with moderate concern, 5 studies with serious concern; not mentioned anything about research reflexivity, sampling strategy, concern about ethical issue and data analysis process)	Minor concern (all 8 studies focused on requirement of bicycle helmet law; conducted in affluent semi-urban and rural areas and HICs 2 continents)	Minor concern (review findings well supported by underlying studies)	Minor concern (8 studies all together offered thin data but lack of confidence in data collection methods and sampling strategy)	Very low confidence	8 studies supported this finding. Data were from studies with serious methodological limitations. Minor concerns about relevance, coherence and adequacy.

helmets as a safety item and not a fashion item.^[35] Women considered helmets as “part of the kit” and wouldn’t prefer to buy a bicycle without a helmet coming along with.^[41] One study mentioned that men perceived helmets to protect only the front part of the head, and hence were less inclined to use them.^[35] Gendered preferences in terms of design, color preference and shell type (of helmets)^[34,35] were reported in a few studies. Teenage girls and women expressed the need for helmets taking into account long hair and the need to have a softer and more cushioned interior^[34–36,40]

Children have reported that mothers were more concerned about their children’s safety than their fathers^[37,46]: “I know a student whose parents are separated. when he lives with his mother, she

makes him wear a bicycle helmet to go to school, while his father lets him go without wearing a helmet.”^[46]

Parenting strategies influenced children’s helmet use behavior (6 studies, moderate confidence)

Parenting strategies influenced use of bicycle helmets. Many parents aimed to inculcate a habit of helmet use in young children.^[35,37] Studies in which parents established a “helmet rule” at an early age reported to have better compliance in children. Some participants expressed that the lack of use of helmet by parents and older children made children reluctant.^[37,40] Parents mentioned, “If I’m not going to wear a helmet and they are questioning me, then what do you say?”^[37]

Multiple parenting strategies were reported: setting rules, role modelling, and anecdotes from experience, or rewarding system. Studies mentioned that many parents expected their older children (9–14 years) to learn from their own experience of helmet usage to avoid peer pressure.^[34,37,42] One study mentioned that when children became assertive about helmet use, they did not get influenced by peers,^[42] whereas some parents preferred proper communication with their children to address peer pressure. A mother tried to make her children understand by using this quote: “It was a little harder to say, ‘well, it doesn’t really matter what someone says to you, what you have to think about is if you had the injury, how we would want you to be protected.’”^[42] Rewards and praises were often used by parents to incentivize helmet use in children.^[37,42] Studies reported that a lack of enforcement of helmet rules on older/experienced children, lack of awareness of helmet legislation, absence of rule in family, and less strictness limited the use of helmets.^[36,37,40,42]

Adoption and enforcement of laws shapes perception and usage of bicycle helmets (8 studies, very low confidence)

Many studies reported that the adoption of bicycle helmet laws would serve as an important facilitator for bicycle helmet usage and this should be twined with proper enforcement to affect behavioral change.^[34,36,37,40,43,46] While some people perceived laws as a compelling obligation, others mentioned rebellious behavior^[34,35] around it. Participants in one study mentioned law enforcement discouraged cyclists, especially those who could not afford to buy helmets, saying that they would be burdened.^[35]

Many bicycle helmet laws are restricted to children and early adolescents, giving the impression that they are no longer needed for other age groups.^[35,40,43,46] However, a few participants also saw age-specific legislation as a strategy to motivate others and make things more feasible, as children were thought to be more open to behavioral change.^[35,43] Participants noted that “if it were possible to increase the use of helmets among children, this could then be extended to other groups, such as adolescents, the elderly, and adults of working age—like a three-stage rocket.”^[44] One study also noted the need for careful planning and implementation of laws including the need for taking a phase-wise approach to gradually increase the acceptance level of bicycle helmets in people.^[35] Parents are often aware of the law in general but not specific things around it.

Discussion

Our evidence synthesis in general shows a lack of qualitative research to understand barriers and facilitators to bicycle helmet use. Our study identified four major themes with varying confidence in each finding. We believe this is the first qualitative evidence synthesis on bicycle helmet use and perhaps the only in the domain of injury prevention, the confidence of the findings of which were rated using GRADE-CERQual. The results of the study are of significance to family physicians,

primary care workers and pediatricians who have to balance promoting physical activity and environment-friendly initiatives with concerns around safety during bicycle use.^[49] Understanding facilitators and barriers to bicycle helmet use would enable countering opposition to helmet use and prevent avoidable injury.

We found that gender was an important aspect which influenced perceived risk of injuries in different settings, leading to differences in helmet use.^[37,42] Parental supervision influenced helmet use in young children.^[35,37,40,42,43] Some of the adult participants reported non-usage of helmet due to lack of clarity on age group in the law for which the restriction was enforced. Interestingly, in one study, children reported that they preferred a bicycling lane or a separate pavement rather than using a helmet.^[47] This pivot towards other dimensions like investment in dedicated road infrastructure for cycling is equally important to increase its use among the population. It supports previous research that creating such an environment facilitated in the uptake of active transportation and augment cyclist safety in untraveled routes.^[50,51]

Our synthesis indicates the need for multi-component and tailored intervention programs to promote bicycle use in different participant groups, taking into considering their varying perceptions. Future studies evaluating the short- and long-term effectiveness of such programs in prevention and reduction of bicycle-related injuries should include qualitative components to enable better understanding of the issue. An equity-oriented approach in future studies is also required.

Existing literature shows that non-legislative programs like helmet subsidies,^[51,52] helmet give away,^[53] helmet education^[54] are cost effective measures to reduce head injuries, but its implementation remains a major challenge. Multi-component and contextually relevant interventions, such as bicycle helmet legislation in conjunction with other interventions, may promote bicycle helmet use.^[54] Our review also shows that there is a need for bicycle helmet manufacturers to focus on design gaps, particularly for warmer and damp climates as well as for women (pertaining to longer hair and more comfort) to be considered. There is also a need for understanding issues around branding and perceived fashion needs when designing helmets. The findings of the study suggest several areas for future inquiry and could make a positive contribution toward increasing overall safety of bicycle users.

We reflected on our own influences on the collection and analysis of data to mitigate personal biases. The team had clinicians and public health researchers. Many authors had been avid bicycle riders as children and/or adolescents, albeit without helmets, as is the prevailing norm in the country. We continually reflected and continually discussed alternative explanations or linkages between concepts to mitigate any researcher bias.

Conclusion

Bicycle-related injuries are an important concern to promote its usage. Our study identified facilitators and barriers which

influenced bicycle helmet use, but the confidence in findings was not high. There is a need for extensive research, especially in low- and middle-income countries. While planning any intervention or promotion strategies, equity issue should be targeted. Effective intervention needs to act on the individual, social, and environmental levels because all play a major role in shaping and sustain helmet use behaviour.

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Conflicts of interest

There are no conflicts of interest.

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Appendices for Facilitators and barriers to bicycle helmet use: A qualitative evidence synthesis

Sucharita Panigrahi, Samina Parveen, Jaya Singh Kshatri, Sanghamitra Pati, Soumyadeep Bhaumik

Contents

Appendix 1: ENTREQ Checklist

Appendix 2 Search Strategy for different databases

Appendix 3: References for studies excluded at full text level

Appendix 4: Equity characteristics in included studies using the PROGRESS Plus framework

Appendix 1: ENTREQ Checklist		
Enhancing transparency in reporting the synthesis of qualitative research: The ENTREQ statement		
Item	Description	Whether reported or not (√/×)
Aim	State the research question the synthesis addresses.	√
Synthesis methodology	Identify the synthesis methodology or theoretical framework which underpins the synthesis and describes the rationale behind the choice of methodology (e.g., meta-ethnography, thematic synthesis, critical interpretive synthesis, grounded theory synthesis, realist synthesis, meta-aggregation, meta-study, framework synthesis). Indicate whether the search was pre-planned (comprehensive search strategies to seek all available studies) or iterative (to seek all available concepts until theoretical saturation is achieved).	√
Inclusion criteria	Specify the inclusion/exclusion criteria (e.g., in terms of population, language, year limits, type of publication, study type).	√
Data sources	Describe the information sources used (e.g., electronic databases (Medline, Embase, CINAHL), grey literature databases (digital thesis, policy reports), relevant organizational websites, experts, information specialists, generic web searches (Google Scholar), manual search, reference lists) and when the searches were conducted; provide the rationale behind using the data sources.	√
Electronic search strategy	Describe the literature search (e.g., provide electronic search strategies with population terms, clinical or health topic terms, experiential or social phenomena related terms, filters for qualitative research, and search limits).	√
Study screening method	Describe the process of study screening and sifting (e.g., title, abstract and full text review, number of independent reviewers who screened studies).	√
Study characteristics	Present the characteristics of the included studies (e.g., the year of publication, country, population, number of participants, data collection, methodology, analysis, research questions).	√

Contd...

Appendix 1: Contd...

Enhancing transparency in reporting the synthesis of qualitative research: The ENTREQ statement

Item	Description	Whether reported or not (√/×)
Study selection result	Identify the number of studies screened and provide reasons for study exclusion (e.g., for comprehensive search, provide numbers of studies screened and reasons for exclusion indicated in a figure/flowchart; for iterative search, describe reasons for study exclusion and inclusion based on modifications of the research question and/or contribution to theory development).	√
Rationale for appraisal	Describe the rationale and approach used to appraise the included studies or selected findings (e.g., assessment of conduct (validity and robustness), assessment of reporting (transparency), assessment of content and utility of the findings).	√
Appraisal term	State the tools, frameworks and criteria used to appraise the studies or selected findings (e.g., existing tools: CASP, QARI, COREQ, Mays and Pope; reviewer developed tools; describe the domains assessed: research team, study design, data analysis and interpretations, reporting).	√
Appraisal process	Indicate whether the appraisal was conducted independently by more than one reviewer and if consensus was required.	√
Appraisal result	Present results of the quality assessment and indicate which articles, if any, were weighted/excluded based on the assessment and give the rationale.	√
Data extraction	Indicate which sections of the primary studies were analyzed and how were the data extracted from the primary studies? (e.g., all text under the headings “results/conclusions” were extracted electronically and entered via a computer software).	√
Software	State the computer software used, if any.	√
No. of reviewers	Identify who was involved in coding and analysis.	√
Coding	Describe the process for coding of data (e.g., line-by-line coding to search for concepts).	√
Study comparison	Describe how the comparisons were made within and across studies (e.g., subsequent studies were coded into pre-existing concepts, and new concepts were created when deemed necessary).	√
Derivation of themes	Explain whether the process of deriving the themes or constructs was inductive or deductive.	√
Quotations	Provide quotations from the primary studies to illustrate themes/constructs, and identify whether the quotations were participant quotations of the author's interpretation.	√
Synthesis of output	Present rich, compelling and useful results that go beyond a summary of the primary studies (e.g., new interpretation, models of evidence, conceptual models, analytical framework, development of a new theory or construct).	√

Appendix 2: Search Strategy for different databases

Ovid MEDLINE(R) <1946 to May 20, 2020>

1. exp Qualitative Research/(54344)
2. (mixed adj (model* or design* or method*)).mp. (33991)
3. Personal Narratives as Topic/(302)
4. Interviews as Topic/(61609)
5. focus groups/or narration/(37527)
6. ((focus adj group*) or qualitative or ethnograph* or (key adj informant*)).mp. (228641)
7. (((semi adj structure*) or unstructured or informal or in-depth or indepth) adj (guide or guides or interview* or discussion* or questionnaire)).mp. (42690)
8. (helmet* or (head adj5 protect*)).mp. (6141)
9. exp Head Protective Devices/(3524)
10. 1 or 2 or 3 or 4 or 5 or 6 or 7 (307082)
11. 8 or 9 (6141)
12. 10 and 11 (110).

Global Health < 1910 to 2020 Week 19>

1. exp Qualitative Research/(0)
2. (mixed adj (model* or design* or method*)).mp. (9688)
3. Personal Narratives as Topic/(0)
4. Interviews as Topic/(0)
5. focus groups/or narration/(0)
6. (((semi adj structure*) or unstructured or informal or in-depth or indepth) adj (guide or guides or interview* or discussion* or questionnaire)).mp. (17625)
7. ((focus adj group*) or qualitative or ethnograph* or (key adj informant*)).mp. (61574)
8. (helmet* or (head adj5 protect*)).mp. (1060)
9. exp Head Protective Devices/(0)
10. 1 or 2 or 3 or 4 or 5 or 6 or 7 (75372)
11. 8 or 9 (1060)
12. 10 and 11 (25).

Embase Classic + Embase < 1947 to 2020 May 20>

1. exp Qualitative Research/(74576)
2. (mixed adj (model* or design* or method*)).mp. (59666)
3. Personal Narratives as Topic/(45094)
4. Interviews as Topic/(151772)
5. focus groups/or narration/(208250)
6. (((semi adj structure*) or unstructured or informal or in-depth or indepth) adj (guide or guides or interview* or discussion* or questionnaire)).mp. (81034)
7. ((focus adj group*) or qualitative or ethnograph* or (key adj informant*)).mp. (368408)
8. (helmet* or (head adj5 protect*)).mp. (8935)
9. exp Head Protective Devices/(5793)
10. 1 or 2 or 3 or 4 or 5 or 6 or 7 (773129)
11. 8 or 9 (8935)
12. 10 and 11 (298)
13. limit 12 to exclude medline journals (24).

Appendix 3: References for studies excluded at full-text level

Citation	Reasons
Caron JG, Rathwell S, Delaney JS, <i>et al.</i> Development, implementation and assessment of a concussion education programme for high school student-athletes. <i>J Sports Sci</i> 2018;36:48-55. doi: https://dx.doi.org/10.1080/02640414.2017.1280180	Wrong population and outcome
Treviño-Siller S, Pacheco-Magaña LE, Bonilla-Fernández P, <i>et al.</i> An educational intervention in road safety among children and teenagers in Mexico. <i>Traffic Inj Prev</i> 2017;18:164-70. doi: 10.1080/15389588.2016.1224344	Results did not highlight specifically for bicycle helmet use
Tetali S, Lakshmi JK, Gupta S, <i>et al.</i> Qualitative study to explore stakeholder perceptions related to road safety in Hyderabad, India. <i>Injury</i> 2013;44:S17-23. doi: 10.1016/S0020-1383 (13) 70208-0	Wrong outcome
Anonymous. Helmets for children: Cycling down the right track. <i>Med Today</i> 2003;4:10.	Full text not available
Davidse RJ, van Duijvenvoorde K, Boele-Vos MJ, <i>et al.</i> Scenarios of crashes involving light mopeds on urban bicycle paths. <i>Accid Anal Prev</i> 2019;129:334-41. doi: 10.1016/j.aap. 2019.05.016	Wrong outcome
Anonymous. A qualitative study amongst parents: the compulsory use of bicycle helmets. Federal Office of Road Safety, Canberra, 1989	Full text not available
Hull, M; Lambert, J; Hendrie D <i>et al.</i> [Summary of papers]:involvement by power to weight ratio for novice and experienced riders: ; Bicycle crashes and three different data sources; Evaluation of compulsory bicycle helmet wearing. Road Safety Researchers Conference, Adelaide, 1993;	Full text not available
Ludwig TD, Buchholz C, Clarke SW. Using social marketing to increase the use of helmets among bicyclists. <i>J Am Coll Health</i> 2005;54:518. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=16050328	Wrong study design
Fenerty L, Heatley J, Young J, <i>et al.</i> Achieving all-age helmet use compliance for snow sports: strategic use of education, legislation and enforcement. <i>Inj Prev</i> 2016;22:176-80. doi: http://dx.doi.org/10.1136/injuryprev-2015-041699	Wrong outcome
Sarmah R.; Nim D.; Factors affecting awareness and perception of youth regarding the public health and hygiene related campaigns through social marketing. <i>Indian J Public Heal Res Dev</i> 2019;10:233-8.	Full text not available
Lastennet, F; Sizun, J; Dobrzynski, M; de Parscau L. [Bicycle helmet effectiveness in children: qualitative analysis of the literature]. <i>Interet du casque Cycl chez l'enfant Anal Qual la litterature</i> 2001;8:1246-50	Different language
Ellena T, Subic A, Mustafa H, <i>et al.</i> The helmet fit index - an intelligent tool for fit assessment and design customisation. <i>Appl Ergon</i> 2016;55:194-207. doi: 10.1016/j.apergo. 2016.02.008	Wrong process and outcome
Johnson M, Charlton J, Oxley J. The application of a naturalistic driving method to investigate on-road cyclist behaviour: A feasibility study. <i>Road Transp Res</i> 2010;19:32-41.	Qualitative data not analyzed
Lajunen T. Barriers and facilitators of bicycle helmet use among children and their parents. <i>Transp Res Part F Traffic Psychol Behav</i> [Internet]. 2016;41:294-301. Available from: http://dx.doi.org/10.1016/j.trf.2015.03.005	Qualitative data not analyzed

Contd...

Appendix 3: Contd...

Citation	Reasons
Otis J, Lesage D, Godin G, Brown B, Farley C, Lambert J. Predicting and reinforcing children's intentions to wear protective helmets while bicycling. <i>Public Health Rep.</i> 1992;107 (3):283-9.	Qualitative data not analyzed
Ledesma RD, Shinar D, Valero-Mora PM, Haworth N, Ferraro OE, Morandi A, <i>et al.</i> Psychosocial factors associated with helmet use by adult cyclists. <i>Transp Res Part F Traffic Psychol Behav.</i> 2019;65:376-88.	Qualitative data not analyzed

Appendix 4: Equity characteristics in included studies using the PROGRESS-Plus framework									
Study	Place of residence	Race/ethnicity/ culture/language	Occupation	Gender, sex	Religion	Education	Socioeconomic status	Social capital	Plus
Howland, 1989 (USA)	Affluent semirural community, Suburban New brand ford area, and racially mixed inner-city Boston neighbourhood, North-eastern United States	Only one school chosen from racially mixed place was reported (not clearly mentioned about any race)	School students from fourth (22/42), fifth (7/42) or sixth grade (13/42)	Equal number of boys and girls	Not reported	Students from fourth (22/42), fifth (7/42) or sixth grade (13/42)	Not reported	Not reported	Not reported
Kakefuda, 2015 (USA)	Northern Colorado town, USA	85% were Anglo Americans	Six health, five public safety, and nine elected officials; five bicycle retailers; nine elementary schools; four parent-teacher organizations (PTOs); four junior and senior high school, and 13 college students; 25 community residents; and five mixed affiliation	40% males and 60% females	Not reported	College, junior and senior high school students; for rest of the participants, not specified.	Not reported	Not reported	Not reported
Loubeau, 1999 (USA)	Affluent urban city north of New York City area, USA	Not reported	School students	17 boys and 18 girls	Not reported	8 th (8) and 7 th (23) graders	Not reported	Not reported	Not reported
Garcia, 2016 (Spain)	Valencia (Spain)	Not reported	School students	Male and female (gender-specific numbers not mentioned for qualitative data)	Not reported	Secondary school	Not reported	Not reported	Not reported
Pierce, 2013 (USA)	USA	African American (14) or Caucasian (3)	Kindergarten and school students	Male (6/17), Female (11/17)	Not reported	Kindergarten (5/17), first grade (12/17)	Low-income families	Not reported	Not reported
Robertson, 2014 (Canada)	Rural Saskatchewan, Canada.	First Nations, vulnerable communities representing rural Saskatchewan	None	Male (7/62), female (55/62)	Not reported	Not reported	Not reported	Not reported	Not reported
Ryan, 2019 (USA)	Urban area Baltimore, Maryland, USA	Predominantly African American, English spoken	School students	Male (7/11), Female (4/11)	Not reported	Not reported	Not reported	Not reported	Not reported
Stevenson, 1992 (Australia)	Dalby, South East Queensland, Australia	Not reported	School Students	Male, female (but numbers not reported)	Not reported	Primary, high schools	Not reported	Not reported	Not reported
Halliday, 1996 (England)	West London and a rural locality (near Banbury, Oxfordshire), England	Not reported	Majority of participants were students (55/84), 22 were employed full-time or part-time, 4 were housewives, 2 unemployed and 1 disabled	Male (41/84), Female (43/84)	Not reported	First and last years of primary school, reported for young teenagers. For adults not reported	Reported as social class for adult and teenage group as AB (9/84), C1 (22/84), C2 (21/84) and DE (16/84)	Not reported	Disabled (1) reported

Contd...

Appendix 4: Contd...									
Study	Place of residence	Race/ethnicity/ culture/language	Occupation	Gender, sex	Religion	Education	Socioeconomic status	Social capital	Plus
Johnson, 2014 (Australia)	Australian Capital Territory (ACT)	Not reported	High proportions of employment, commuter cyclists; either working full-time or part-time. Some full-time students, and some part-time students	Male (63.2%), female (not reported)	Not reported	Secondary school, technical school or TAFE	\$41,000-\$75,000; \$76,000-\$100,000; \$101,000-\$150,000; \$151,000 and over	Not reported	Not reported
Nolen, 2010 (Sweden)	Motola, Sweden	Not reported	Bicycle Law Co-ordinating Committee: 1 politician, 3 municipality officials, 4 external members (2 researchers, 2 national officials)	4 men and 4 women	Not reported	Not reported	Not reported	Not reported	Not reported
Martin, 2016 (USA)	San Francisco Bay Area, San Jose California, USA	Not reported	Experts: bikesharing operator, policymakers, government agency personnel, non-profit personnel, and emergency service personnel (numbers not specified); BABA members: Drivers, bicyclist	5 men, 4 women (FGD 1); 1 woman, 6 men (FGD 2)	Not mentioned	Not mentioned	Not reported	Not reported	Not reported
Hendrickson, 1997 (USA)	Urban or adjacent to urban area, Metro area, USA	35% Anglo, 24% African American, 15% Hispanic and 26% Asian American	35% health professionals; others not reported	Male (3/34), female (31/34)	Not reported	Not mentioned	Not reported	Not reported	Not reported
Piotrowski, 2020 (Canada)	Central Canada	culturally varied population were included, but not specified. English speaking is compulsory	Elementary school students; for other participants not specified.	Male (50/144) Female (62/144), 5 not specified	Not reported	Not mentioned	Mentioned but Not specified	Not reported	Not reported
Caroline C. Piotrowski, 2020 (Canada)	Neighbor community, Canada	Ethno-cultural varied population were selected but not specified in the study; French and English language speakers	None	Male (32/76) Female (41/76), 3 not specified	Not reported	Not mentioned	Mentioned but not specified	Not reported	Not reported