A Systematic Review on the Effectiveness of Clinician-Directed Interventions to Improve Compliance to Post-Polypectomy Surveillance Guidelines

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Keywords

Colonic polyp · Rectal polyp · Colonoscopy · Surveillance · Guideline adherence

Abstract

Introduction: Clinical practice guidelines recommend periodic colonoscopy surveillance following colorectal adenoma excision. Inappropriate use of post-polypectomy surveillance (PPS) is common and lead to improper resource utilization. The aim of this review was to identify structured interventions which can affect PPS practises and to evaluate the effectiveness of these various interventions in improving clinician adherence to PPS guidelines. **Methods:** A computerized search was performed to identify relevant studies between 1997 and November 2020. Two investigators identified eligible studies and extracted data independently. The quality of the included studies was assessed by the Newcastle-Ottawa risk of assessment scoring system. **Results:** The search identified 5,602 citations. Forty-one articles were retrieved for full-text analysis and 7 studies met the inclusion criteria. Compliance to PPS guidelines was higher following interventions which included medical education, specialist nurse coordinators facilitation, continuous quality improve-

ment, and clinical decision support systems. **Conclusion:** This study demonstrates that medical education, specialist nurse coordinators, continuous quality improvement, and clinical decision support systems are effective in improving clinicians' compliance to PPS guidelines, and are associated with reduction in over- and underutilization of colonoscopy surveillance resources.

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Introduction

Adenomatous polyps are recognized as precursors to colorectal cancer [1] and complete excision of such lesions during colonoscopy have been shown to be effective in reducing colorectal cancer incidence and mortality [2]. Individuals with newly diagnosed adenomas are at an increased risk of subsequent polyps [3]; therefore, they would be encouraged to enrol on post-polypectomy surveillance (PPS) and the intensity of surveillance is dependent upon specific endoscopic and histological features of the polyps. Recommendations for PPS are well established through international societal guidelines, but numerous studies indicate that the actual practice patterns

Table 1. PICO worksheet and search strategy

PICO element	Search strategies
Population	Clinicians, comprising mainly of gastroenterologists and general surgeons, who manage patients with colorectal polyps
Intervention	Interventions to improve guideline adherence, which broadly fall under the following categories <ul style="list-style-type: none"> • Education on polyp surveillance through reading materials like leaflets and pamphlets, online resources or through dedicated educational meetings such as lectures, seminars, or workshops • Continuous quality improvement programme – this generally involves education in regular educational or departmental meetings and measurement of performance and provision of feedback • Assistance in making clinical decisions using CDSS
Comparison	Population continues to practise as normal with no alterations in their routine clinical practice
Outcomes	Main outcome <ul style="list-style-type: none"> • Guideline-compliant PPS colonoscopies requested by the clinician following adenoma detection, <i>n</i> Additional outcomes <ul style="list-style-type: none"> • Colonoscopies performed earlier than recommended (overutilization), <i>n</i> • Colonoscopies performed later than recommended (underutilization), <i>n</i> • Patients who had no recommendations, <i>n</i>
PICO, P, population; I, intervention[s]; C, comparison; O, outcome.	

are highly inconsistent as significant numbers of surveillance colonoscopies are performed either earlier or later than recommended [4]. These findings highlight the need to explore interventions which could affect change in clinicians' behaviour and to improve guideline adherence for polyp surveillance. There is no systematic review to date which has evaluated the effectiveness of interventions in improving guideline-adherence specific to PPS. The aim of our study was to appraise published observational studies to determine the effectiveness of specific interventions devised to improve PPS guideline-adherent practises.

Methods

Selection and Eligibility Criteria

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5] to formulate the basis of prespecified eligibility criteria using the PICO worksheet and search strategy (Table 1). We included cohort studies, randomized controlled trials, and quasi-randomized trials which have been peer-reviewed and published in the English language between 1997 and the November 2020. Articles which were published after 1997 were only considered as this represented the date of the first published guideline on polyp surveillance. All studies which assessed the effectiveness of various interventions to improve clinicians' adherence to PPS in adult patients were included in this study. Articles which involved colonoscopy surveillance in paediatric patients were excluded.

Search Methods for Identification of Studies

Three electronic databases were searched (PubMed, Cumulative Index to Nursing and Allied Health Literature [CINAHL] and Cochrane Library) with the last search performed on the November 24, 2020. We searched for the following terms: adenomatous polyp, colonic polyp, rectal polyp, colorectal neoplasms, colonoscopy, guideline adherence, clinical practice guideline, clinical protocols, clinical decision, surveillance, compliance, colonoscopy appropriateness, intervention, education, decision-making, decision support, awareness, reminder, and audit. We modified and used appropriate mesh terms in the databases with the assistance of the health librarian at University of Malaya. Online supplementary Table S1 (for all online suppl. material, see www.karger.com/doi/10.1159/000520859) presents an example of a search strategy performed in PubMed where 2,371 articles were found. We screened titles and abstracts using the eligibility and exclusion criteria. Potential eligible articles for data extraction were identified after full-text review. Two reviewers (T.L.K. and X.H.K.) independently performed these 2 stages of screening. Disagreements were resolved by consensus or after consultation with a third reviewer (I.N.H.). A third reviewer (I.N.H.) independently reviewed the final included articles to confirm they met the inclusion criteria. The review was registered in PROSPERO on January 6, 2021, prior to the analysis being undertaken (registration number CRD42021218000) and IRB was not required.

Data Collection and Analysis

From the full text, 2 authors independently extracted data from the eligible studies using a pre-tested data extraction form. Disagreement was resolved by consensus or third-party adjudication. To assess the quality of the methodology used in the studies, the Newcastle-Ottawa Scale was used and scores were allocated under the domains of selection, comparability, and outcome [6]. The quality of the studies (good, fair, and poor) was rated by awarding

Fig. 1. PRISMA study flow diagram.

stars in each domain according to the guidelines of the Newcastle-Ottawa Scale. A “good” quality score required 3 or 4 stars in selection, 1 or 2 stars in comparability, and 2 or 3 stars in outcomes. A “fair” quality score required 2 stars in selection, 1 or 2 stars in comparability, and 2 or 3 stars in outcomes. A “poor” quality score reflected 0 or 1 star(s) in selection, or 0 stars in comparability, or 0 or 1 star(s) in outcomes.

Outcome Analysis

The primary outcome was guideline-compliant PPS colonoscopy requests following adenoma detection. The secondary outcomes were PPS overutilization (colonoscopies performed earlier than recommended), PPS underutilization (colonoscopies performed later than recommended), and patients who did not have any follow-up recommendations.

Odds ratio and 95% confidence intervals were used as summary measures for dichotomous outcomes. Statistical analysis was performed using SPSS statistical software.

Results

Figure 1 summarizes the articles selected for the review. Initial database searches identified 5,601 relevant publications, with 1 additional article identified by

searching through the bibliographies of included studies. Five thousand one hundred and fifty-two articles were excluded based on titles, abstracts, duplicate studies, and other reasons (reviews, non-randomized studies, or not relevant to our analysis). Forty-one potentially relevant studies were identified for full-text analysis. Sixteen studies lacked an intervention component as they were purely observational studies, 9 studies did not report on clinicians’ practises following intervention, and a further 9 studies did not measure the effectiveness of an intervention in altering clinicians’ PPS compliance. Finally, 7 studies were included for the systematic review.

Study Characteristics

Three studies were conducted in the USA and 1 study from Australia, Italy, Israel, and the UK, respectively (Table 2). All studies used a before-after study design with 4 studies adopting a prospective study design, 2 retrospective and 1 combined retrospective audit, and prospective follow-up. The duration of pre-interventional and post-interventional period ranged between 60 and 913 days

Table 2. Summary of the included studies

Author [ref.]	Country of study	Study type	Pre-intervention		Post-intervention		Type of clinicians	Type of intervention	Surveillance guideline used
			date of enrolment	colonoscopies performed, <i>n</i>	date of follow-up	colonoscopies performed, <i>n</i>			
Bampton et al. [8]	Australia	Prospective pre and post test	Sep – Dec 1999	100	Feb – May 2000	100	Specialists	(i) Nurse coordinator – reviews NHMRC & clarifies clinician's follow-up decisions (ii) Guidelines hand-out	NHMRC
Sanaka, 2006 [10]	USA	Retrospective audit and prospective pre and post test	Feb – Jul 2003	278	Sep 2003 – Feb 2004	242	Gastroenterologist	(i) CQI programme (ii) Display guideline charts & distribute wallet cards	ACG & AGA
Grassini et al. [7]	Italy	Prospective pre and post test	Jul 2004 – Apr 2005	495	Sep 2005 – May 2006	522	Primary care clinicians	(i) Education – 1 day course (ii) Summary of course & guidelines (posted out to non-attendees)	ASGE
John et al. [9]	UK	Prospective audit	Not stated	25	Not stated	28	Specialists	(i) CQI programme (ii) Display guideline charts	BSG
Dorn et al. [12]	USA	Retrospective pre and post test	Feb – Oct 2015	487	Dec 2015 – Aug 2016	481	Hospital gastroenterologist	EMR & CDSS	USMSTF
Magrath et al. [13]	USA	Retrospective pre and post test	Jan 2011 – Nov 2013	1,822	Oct 2014 – Sept 2015	1,320	Gastroenterologist, colorectal surgeons	EMR & CDSS	USMSTF
Naftali et al. [11]	Israel	Prospective pre and post test	Not stated	266	Not stated	254	Gastroenterologist	(i) CQI programme (ii) Electronic reporting form	Not stated

NHMRC, Australian National Health and Medical Research Council; ACG, American College of Gastroenterology; AGA, American Gastroenterological Association; ASGE, American Society for Gastrointestinal Endoscopy; BSG, British Society of Gastroenterology; USMSTF, US Multi-society Task Force.

Table 3. Reported outcomes of intervention on clinicians' compliance to PPS guidelines

Author	Pre-intervention				Post-intervention				OR	95% CI
	appropriate		inappropriate		appropriate		inappropriate			
Bampton et al. [8]	38	(38)	62	(62)	96	(96)	4	(4)	39.2	(13.3–115.2)
Sanaka et al. [10]	159	(57)	119	(43)	196	(81)	46	(19)	3.2	(2.1–4.8)
Grassini et al. [7]	381	(77)	114	(23)	147	(97)	4	(3)	3.1	(2.0–4.6)
John et al. [9]	4	(16)	21	(84)	13	(46)	15	(54)	3.2	(2.1–4.8)
Dorn et al. [12]	403	(83)	84	(17)	412	(86)	69	(14)	1.3	(0.9–1.8)
Magrath et al. [13]	1,410	(77)	412	(23)	1,117	(85)	203	(15)	1.6	(1.3–1.9)
Naftali et al. [11]	174	(65)	92	(35)	199	(78)	55	(22)	1.9	(1.3–2.8)

Time intervals to the next surveillance colonoscopy were benchmarked against PPS guidelines to determine appropriateness of requests. Data is *N* (%). CI, confidence interval; OR, odds ratio.

and 60–364 days, respectively, and the number of colonoscopies performed in each study ranged between 25 and 1,822. All the included studies were conducted in the hospital setting except for 1 study which focused upon primary care physicians. The articles were published between the years 2002–2020. Two studies utilized the US Multi-Society Task Force (USMTF) guideline on colorectal cancer, and 2 studies, predating the USMTF, utilized the American Society for Gastrointestinal Endoscopy, American College of Gastroenterology, and American Gastroenterological Association as the benchmark for best clinical practice. One study benchmarked their practice against the British Society of Gastroenterology and the other against the Australian National Health and Medical Research Council.

Three of the studies described using continuous quality improvement (CQI) initiatives to effect change in PPS requesting practises. The process involved evaluating baseline clinical practice through an audit process, sharing and discussing the results in a group meeting, and formulating remedial measures for improvement. The other 2 studies investigated the role of clinical decision support systems (CDSSs) which were integrated into the electronic medical records (EMR) to promote guideline-adherent practice amongst clinicians who routinely request surveillance colonoscopies using the EMR. One study described an education programme, and another examined the role of a specialist nurse coordinator in modifying surveillance colonoscopy requesting practises. All studies reported the main outcome of interest which is appropriate surveillance colonoscopy in keeping with societal guidelines. Three studies examined the inappropriate requests by further subcategorizing them into those scheduled too

early constituting overuse, too late constituting underuse, or no follow-up surveillance colonoscopy was arranged.

Summary of Study Findings

The study results are summarized in Table 3. In all studies, intervention was associated with increased guideline-adherent practises. In one of the studies where the effectiveness of a dedicated 1-day educational programme delivered to primary care physicians was evaluated, this was associated with a statistically significant improvement in guideline-adherent colonoscopy requests from 77 to 97% ($p \leq 0.001$) [7]. In another study by Bampton et al. [8] where a dedicated specialist nurse coordinated PPS colonoscopy requests, these measures resulted in marked improvement in guideline compliance from a baseline of 38–96%. The numbers of colonoscopies performed too early were reduced by approximately 9-fold and none of the clinicians had made requests which were too late or had neglected to arrange for subsequent follow-up colonoscopies (Table 4).

Three studies examined the effect of CQI to improve guideline compliance amongst clinicians. Two studies adopted an approach to increase visibility of guidelines by displaying laminated guideline charts in clinics, and one of these studies also provided clinicians with quick reference wallet cards. By displaying guidelines in laminated charts in the clinics, John et al. [9] demonstrated that the number of guideline-adherent colonoscopy requests increased from 16 to 46% ($p = 0.017$). In addition to displaying guideline charts in the endoscopy suites, Sanaka et al. [10] also distributed wallet-sized guideline cards to clinicians. This study showed that the guideline-compliance rates improved from 57.2% pre-intervention

Table 4. Reported outcomes of intervention on inappropriate PPS colonoscopies based on utilization pre- and post-intervention

Author	Pre-intervention						Post-intervention					
	overutilization		underutilization		no recommendation		overutilization		underutilization		no recommendation	
Bampton et al. [8]	37	(37)	1	(1)	24	(24)	4	(4)	0	(0)	0	(0)
Magrath et al. [13]	263	(14)	85	(5)	64	(4)	143	(11)	41	(3)	19	(1)
Naftali et al. [11]	66	(25)	26	(10)	Not stated	Not stated	48	(19)	7	(3)	Not stated	Not stated

Inappropriate PPS were categorized into overutilization (too soon), underutilization (delayed), and no recommendation (no follow-up colonoscopy). Data are *N* (%).

to 81% post intervention ($p < 0.001$) [10]. The benefit of CQI was also demonstrated by the study by Naftali et al. [11] where PPS guideline-adherence improved from 65 to 78% post intervention ($p = 0.001$). The study by Naftali et al. [11] also classified inappropriate utilization based on intensity of surveillance and the data showed that 71% of the inappropriate requests were due to colonoscopies being scheduled too early. Following CQI implementation, not only was the overall compliance rate better, but the proportion of surveillance colonoscopies scheduled too early and late were reduced by 24 and 70%, respectively.

Two studies investigated the effectiveness of decision support systems incorporated into EMR platforms to assist clinicians in scheduling PPS colonoscopies. Both studies used different information technology (IT) systems to accommodate for inter-institutional variations in endoscopy workflow processes. The system utilized by Dorn et al. [12] would automatically recommend the interval to the next surveillance colonoscopy when the endoscopists generated a post-consultation report to the patient and the referring physician using the EMR. In contrast, Magrath et al. [13] utilized an automated system where the CDSS would initially capture data from colonoscopy and pathology reporting systems, decide on the recommended PPS interval, and subsequently state these recommendations on letters to patients and referring physicians. Both studies demonstrated that CDSS incorporated into EMR can improve overall guideline-adherent practises for PPS. However, the improvement in guideline-adherence was rather modest in both studies, with Magrath et al. [13] reporting compliance of 77.4% versus 84.6% ($p < 0.001$) in the pre- versus post-intervention cohort, and a non-significant difference of 82.9% versus 85.7% ($p = 0.72$) reported by Dorn et al. [12] The study by Magrath et al. [13] also categorized the inappropriate surveillance colonoscopies based on utility and

they found that 65–70% of colonoscopies were scheduled too early, as illustrated in Table 4. Following CDSS implementation, the observed overall guideline compliance rates improved, but the proportion of surveillance colonoscopies which were scheduled too late or had no recommendations remained unchanged at 20% and 10–15%, respectively.

Risk of Bias Assessment

Table 5 provides quality scores for the studies, assessing risk of bias using the Newcastle-Ottawa criteria. Four studies were of good quality, 2 were of fair quality, and one was of poor quality. Majority of the study cohort consisted of hospital clinicians who requested colonoscopies, but the single Italian study focused on primary care physicians who were entitled to request endoscopies directly. However, 2 of the hospital-based studies did not specify the clinicians or specialists who would have access to colonoscopy requests. In a pre-post study design, this may introduce confounders particularly if different cohort of clinicians were studied over 2 different time intervals. Five studies did not specifically report the level of exposure of intervention in the intervention groups, and therefore the changes observed in the post-intervention period could be due to modification in behaviour in response to their awareness of being observed. The assessment of outcome in all studies was carried out by independent assessors, mainly by the investigators of the study, and the assessors were blinded. One study included a comparably low number of colonoscopies, thus the comparatively low number of observed events of interest could result in error of estimates of the true effect of the intervention. Although all the studies had sufficient follow-up duration for events of interest to be observed and measured, none calculated the required minimum study sample size for each study. This might

Table 5. Risk of bias assessment (Newcastle-Ottawa Quality Assessment Scale criteria)

Study	Comparability of cohorts			Outcome		Quality score
	representativeness of exposed cohort	selection of the non-exposed cohort from same source as exposed cohort	ascertainment of exposure	outcome of interest was not present at start of study	assessment of outcome	
Bampton et al. [8]	Exposed cohort were hospital clinicians who request colonoscopies, but there was no attempt in identifying specific cohort of clinicians involved in the study	Yes – specialists were from the same hospital ★	No specifics on exposure to intervention – the clinical nurse coordinator only approached selected clinicians who were non-compliant with guidelines	Yes ★	No information is provided to determine whether the clinicians involved in the pre- and post-intervention periods were identical	Fair
Dorn et al. [12]	Truly representative cohort comprising endoscopists who routinely perform colonoscopies and write colonoscopy reports ★	Yes – the same clinicians were involved in the pre and post-intervention period of the study ★	Yes – all the endoscopists enrolled on the study were exposed to the intervention ★	Yes ★	The same cohort of endoscopists were involved in the pre- and post-intervention evaluation ★	Good
Grassini et al. [7]	Focused group (only primary care physicians in a rural Italian community)	Yes – the same cohort of primary care physicians were in the pre- and post-intervention period of the study ★	No – 37.6% of the invited participants attended the course. The exposure to the intervention amongst the non-attenders was not assessed	Yes ★	The same cohort of primary care physicians were involved in the pre- and post-intervention evaluation ★	Fair
John et al. [9]	No details to describe the study cohort	No available information to determine whether the clinicians in the pre- and post-intervention period are identical	No – there were no data to evaluate the exposure of clinicians to intervention	Yes ★	No information is provided to determine whether the clinicians involved in the pre- and post-intervention periods were identical	Poor
Magrath et al. [13]	Truly representative cohort comprising endoscopists from gastroenterology and colorectal surgery faculty who routinely perform colonoscopies and write colonoscopy reports ★	Yes – participants were drawn from the same pool of endoscopists who perform and report colonoscopies ★	Yes – 90% of colonoscopy requests made in the post-intervention period used the intervention ★	Yes ★	No information is provided to determine whether the clinicians involved in the pre- and post-intervention periods were identical	Good

Table 5 (continued)

Study	Selection	representativeness of exposed cohort	selection of the non-exposed cohort from same source as exposed cohort	ascertainment of exposure	outcome of interest was not present at start of study	Comparability of cohorts	Outcome		Quality score
							assessment of outcome	follow-up long enough for outcome to occur	
Natfali et al. [11]	Truly representative cohort comprising consultant gastroenterologists who perform colonoscopies ★	Yes – participants were drawn from the same pool of endoscopists who perform colonoscopies ★	No – There were no data to evaluate the exposure of clinicians to intervention	Yes ★	The same cohort of endoscopists were involved in the pre- and post-intervention evaluation ★	Independent blinded assessment ★	Yes (3 months pre- and post-period) ★	Subjects lost to follow-up unlikely to introduce biased- (349 pre-vs 297 post) ★	Good
Sanaka et al. [10]	Truly representative cohort comprising gastroenterologists including attending physicians and fellows in training ★	Yes – participants were drawn from the same pool of endoscopists who perform colonoscopies ★	Yes – all the endoscopists enrolled on the study were exposed to the intervention ★	Yes ★	The same cohort of endoscopists were involved in the pre- and post-intervention evaluation ★	Independent blinded assessment ★	Yes (5 months pre- and post-period) ★	Subjects lost to follow-up unlikely to introduce biased- (278 pre-vs 242 post) ★	Good

Good quality: 3 or 4 stars (F) in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome/exposure domain; fair quality: 2 stars in selection domain AND 1 or 2 stars in comparability domain OR 0 or 1 stars in outcome/exposure domain.

introduce error, particularly in the accuracy of the estimated true effect of the various interventions as reported by these studies.

Discussion/Conclusion

Numerous studies have reported the inappropriateness of repeated colonoscopies for the purpose of PPS [4, 14], and many have stressed the necessity to address this issue through targeted interventions. We present our study which is the first to report a systematic review on published articles examining interventions which have been trialled to improve compliance for PPS. All 7 studies included in our systematic analysis, reported improvement in guideline compliance during the post- versus pre-intervention period. The interventions which have been tested can be broadly categorized into medical education, CQI initiatives or computer-based decision assistance programmable modules such as a CDSS and clinical nurse coordinators.

The role of the endoscopy nurse coordinator has been developed to facilitate the delivery of holistic and patient-centred care by improving interdisciplinary collaboration between healthcare professionals. Nurse coordinators can facilitate clinical decision-making in keeping with guidelines by providing suggestions for further management based on clinical guidelines when relaying pertinent investigation results and clinical information to the clinician. However, limitation to the widespread adoption of nurse coordinators may be hindered by physician acceptance [15], increased workload for nurses, and financial implications of additional workforce.

CQI programmes are characterized by a structured approach to evaluate current practice and to improve systems and processes to achieve the desired outcome and vision for the desired future state [16]. The importance of well-timed polyp surveillance was highlighted in monthly audit meetings, and perceived shortfalls in clinical practice were discussed and remedial measures were formulated and agreed by the attendees. The CQI studies demonstrated significant improvement in guideline compliance, regardless of the reported initial baseline compliance rates, but the actual significance and impact of the beneficial effect of CQI in clinical practice was rather variable and the actual clinical significance is debatable. Despite highlighting deficits in current clinical practice and providing feedback in monthly audit meetings, John et al. [9] merely achieved overall guideline-adherence of <50% post intervention. The compliance rates in the oth-

er 2 CQI studies approached 80% post intervention, but one of these studies already had a pre-existent respectable compliance rate of 65% prior to the onset of the study. All 3 studies shared the same weakness of confounding from the Hawthorne effect, a phenomenon which is related to enhanced performance from just being observed. This flaw is intrinsic in most CQI studies utilizing a before and after design, as the study participants would be informed of their shortfalls in clinical practice and their heightened awareness of subsequent monitoring would naturally confound findings of improvement in performance regardless of intervention. Furthermore, 2 of the CQI studies utilized more than 1 intervention in their respective studies, thus deciphering whether a particular intervention is more effective than the other is not possible. A further weakness includes the lack of published long term follow-up data following publication of these studies. It is unclear whether the reported improvements in practice are sustainable over a prolonged period, particularly where the intervention comprised a one-off educational session or sending a single reminder letter. This is particularly relevant given that up to 70% of organizational change is not sustained [17], and multiple studies from the National Health Service in the UK have found that 33% of quality improvement projects are abandoned after 1 year of completion [16, 18].

The increasing adoption of EMR facilitates incorporation of CDSS into health IT systems. Studies have shown that CDSS can effectively prevent deep-vein thrombosis, reduce medication errors, and improve medical guideline adherence [19, 20]. Both studies by Magrath et al. [13] and Dorn et al. [12] showed improvement in guideline compliance following the introduction of a CDSS into the EMR, albeit the observed beneficial effects were marginal. CDSS use was also associated with a decrease in the proportion of colonoscopies which had no subsequent follow-up recommendations or reappointments which were scheduled far too late. This effect could potentially have prevented high-risk patients from developing future advanced polyps or interval cancers. Although both studies provide supportive evidence for CDSS in PPS, the limitations of the study design being single-centred, retrospective, and quasi-experimental nature, could introduce temporal confounders which may be unrelated to the intervention. In theory, CDSS could overcome the challenges faced by CQI, where sustained improvement in clinical practice can be driven by algorithm-based IT applications. However, CDSS can also be viewed as infringing upon a clinician's choice to opt for what may be deemed best for a particular patient. In clinical practice,

decisions may at times contravene stipulated guidelines but such decisions should be rational, valid, and justifiable. Allowances are typically built into CDSS for users to override the system thus allowing for clinicians to bypass the support tool and negate its intended beneficial role. Magrath et al. [13] demonstrated that in 10% of cases where surveillance colonoscopies were requested without CDSS assistance, the compliance rates for non-CDSS users were significantly lower at 63% versus 87% among the CDSS users. Other challenges may be encountered during development and deployment of CDSS which can be complex, costly, and time-consuming as these programmes would have to be custom-built specifically for individual healthcare institutions to ensure systems compatibility with the multitude of pre-existent healthcare IT systems currently in use [11]. Furthermore, there is evidence that embedding decision support at the point of decision making does not necessarily predict success, possibly due to alert fatigue [21]. This highlights that CDSS alone is not the panacea to enforce guideline-adherent practises. End-user empowerment is crucial to encourage adoption of new digital solutions, and the key is to engage and to encourage stakeholder involvement throughout the development of the CDSS to ensure that the final solution gains wide-based user support.

The present study has several limitations. Despite an extended search, the small number of studies fulfilling the study criteria presents a limitation to the assessment of the effectiveness of the described interventions. Evidence for education alone or assistance from nurse coordinators was derived from single institutional observational studies, thus the evidence base for such interventions is rather limited and raises doubt on the reproducibility of similar results in other institutions. Similarly, the data for CDSS and CQI were derived from relatively small numbers of studies, all with differing study designs. Three studies shared common features synonymous with CQI, but each utilized combination of differing interventions, thus care should be taken when interpreting the results from these studies. The objective of this review was to uncover various interventions which have demonstrated effectiveness in influencing guideline compliance for PPS. Whilst we acknowledge that the limitation of this study is the inherent heterogeneity posed by including different interventions, thus invalidating any direct comparisons between studies and pooled analysis, this study has identified structured interventions through a systematic and unbiased research methodology in keeping with the PRISMA protocol. Besides this, our study may also be subject to publication bias as authors of the selected studies would

choose to write up ideas from their hospitals where interventions were perceived to have worked, rather than specifically setting up and designing studies to test the effectiveness of individual methodologies from first principles. However, given these limitations, we feel that our systematic review provides an insightful overview, highlights the lack of high-quality evidence, and provides direction for future research in this area.

While acknowledging a clinician's clinical reasoning and judgement in providing holistic and patient-centred care is paramount, the inappropriate use of endoscopy resources (as judged by non-adherence to internationally accepted guidelines) incurs higher medical costs, deprives others of necessary treatment, and most importantly, confers no benefit to the patient. By reducing unnecessary scopes and lengthening the overall mean surveillance interval from 4.5 years to 5.2 years, change in clinical practice could result in 14% reduction in surveillance colonoscopies performed equating to a healthcare cost saving of USD 171,331 per annum [10]. Our study demonstrates that medical education, nurse practitioners, CQI, and IT-based solutions are effective in improving clinicians' compliance to PPS guidelines and provides direction for future prospective randomized studies to strengthen the evidence base for such interventions.

Acknowledgement

The authors would like to thank Dr. Ranitha Hisham Shunmugam for providing her advice on performing literature searches. They would also like to thank UMSC CARE research grant (PV022-2020) for their support.

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Statement of Ethics

An ethics statement is not applicable because this study is based exclusively on published literature.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

This article is not funded by any grants and organization.

Author Contributions

T.L.K. contributed to conception and design; all authors contributed to analysis and interpretation of the data; T.L.K. contributed to drafting of the article; X.-H.K. and I.H. contributed to critical revision of the article for important intellectual content; all authors gave final approval of the article.

Data Availability Statement

All data generated or analysed during this study are included in this article and its online supplementary material. Further enquiries can be directed to the corresponding author.

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