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A tailored approach to horizon scanning for cancer medicines

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ABSTRACT

Background: Horizon scanning (HS) is the systematic identification of emerging therapies to inform policy and decision-makers. We developed an agile and tailored HS methodology that combined multi-criteria decision analysis weighting and Delphi rounds. As secondary objectives, we aimed to identify new medicines in melanoma, non-small cell lung cancer and colorectal cancer most likely to impact the Australian government's pharmaceutical budget by 2025 and to compare clinician and consumer priorities in cancer medicine reimbursement.

Method: Three cancer-specific clinician panels (total n = 27) and a consumer panel (n = 7) were formed. Six prioritisation criteria were developed with consumer input. Criteria weightings were elicited using the Analytic Hierarchy Process (AHP). Candidate medicines were identified and filtered from a primary database and validated against secondary and tertiary sources. Clinician panels participated in a three-round Delphi survey to identify and score the top five medicines in each cancer type.

Results: The AHP and Delphi process was completed in eight weeks. Prioritisation criteria focused on toxicity, quality of life (QoL), cost savings, strength of evidence, survival, and unmet need. In both curative and non-curative settings, consumers prioritised toxicity and QoL over survival gains, whereas clinicians prioritised survival. HS results project the ongoing prevalence of high-cost medicines. Since completion in October 2021, the HS has identified 70 % of relevant medicines submitted for Pharmaceutical Benefit Advisory Committee assessment and 60% of the medicines that received a positive recommendation.

Conclusion: Tested in the Australian context, our method appears to be an efficient and flexible approach to HS that can be tailored to address specific disease types by using elicited weights to prioritise according to incremental value from both a consumer and clinical perspective.

Policy summary: Since HS is of global interest, our example provides a reproducible blueprint for adaptation to other healthcare settings that integrates consumer input and priorities.

1. Introduction

Timely and affordable access to novel effective medicines is important to clinicians and people with cancer. In cancer medicine, equitable access to high-cost emerging medications is particularly emotive given the often urgent timeframes imposed by the nature of the disease [1]. Navigating these barriers to treatment is becoming increasingly difficult as the rising costs of cancer care challenge the financial sustainability of healthcare systems globally. As a result, health technology assessment (HTA) and regulatory processes are under ever greater scrutiny. In Australia, the Federal Government has commissioned an independent review of the HTA system [2], aiming to improve time to access and ensuring current HTA methods are fit for purpose given the rapid evolution of the treatment landscape.

For context, Australians access a comprehensive list of medicines through the taxpayer funded Pharmaceutical Benefits Scheme (PBS). PBS-listed medicines, including high-cost therapies, are heavily subsidised with a fixed co-payment of AUD$30 per prescription (indexed annually) [3]. However, before PBS-listing, medicines must go through a regulatory and reimbursement process similar to The Netherlands, Canada, United Kingdom, Germany, and France. The Australian Government relies on recommendations on safety, cost-effectiveness, and clinical effectiveness from the Therapeutics Goods Administration (TGA), National Blood Authority, Medical Services Advisory Committee (MSAC), and Pharmaceutical Benefits Advisory Committee (PBAC) to help navigate the competing interests around equitable access and cost. These assessments take time and resources, and although the processing timelines of Australia's advisory agencies are comparable to other countries [4], they have been slow to adapt to the rising complexity and number of submissions each year.

Globally, between 2012 and 2018, there were 72 new medicines approved for use in the treatment of solid tumours and haematological cancers. That number has already been exceeded in three years with 87 cancer medicines approved from 2019 to 2021 [5]. Regulatory delays in the Australian system have often been criticised by stakeholders with a typical cancer medicine submission taking 20.5 months from initial PBAC submission to listing, and requiring on average 1.7 resubmissions [6] prior to a positive recommendation. It is, however, worth noting that a significant proportion of the delay to listing lies outside the control of PBAC, with fiscal negotiations between the Federal Government and the submission Sponsor after a positive PBAC recommendation taking 7.4 months on average [7].

With the rise in number of high-cost therapies, improving Australian's access to cost-effective novel cancer medicines with meaningful clinical benefits will involve reform of current HTA processes. The implementation of a linked formal horizon scanning (HS) programme is a logical inclusion in this reform. HS is the systematic identification of innovations and technologies to forecast clinical and socioeconomic impact and prioritise evidence development and appraisal. The type of HS, and hence methodology, will vary based on the focus of the output. A micro level HS aims to identify individual therapies, and is most often used for resource planning [8] (Supplementary Table S1). HS should be adapted to suit the requirements of the end user to ensure outputs have a tangible impact on health policy and planning [9]. Historically, the use of HS within the regulatory process has been better integrated amongst European and Northern American countries, albeit with varying methodologies and resource requirements [10]. In Australia, previous national attempts on the micro level have not been sustained. Currently this function is performed by university-based HTA groups and professional societies who operate in isolation with differing processes for HS.

Therefore, we sought to develop a transparent and agile methodology for HS of cancer medicines that could be tailored to specific diseases and target populations. We aimed to better reflect the values of people with cancer by working alongside a consumer panel to develop prioritisation criteria. Secondary objectives were to identify promising pipeline medicines and to observe the differences between clinician and consumer priorities in cancer medicine reimbursement.

2. Methodology

The HS was conducted from April to October 2021 and had two phases (Fig. 1): phase one involved establishing consumer and clinician panels to define prioritisation criteria. In phase two, we identified the top five therapies were most likely to impact the Australian healthcare system by 31 December 2025. Analytic Hierarchy Process (AHP) [11], a standardised tool for multicriteria decision analysis (MCDA), with Delphi methodology was used to elicit criteria weights and select the five therapies. The HS focussed on colorectal cancer (CRC), melanoma and non-small cell lung cancer (NSCLC) due to the anticipated high volume of new medicine submissions. The HS process had three variables that

facilitated relevant outputs for the target population. First, by involving consumers, who are important stakeholders in reimbursement decisions, in the development of prioritisation criteria. Second, by targeted engagement of clinical panellists who were recognised content experts in relevant fields. Third, by using AHP to elicit criteria weights, we better reflected the nuances of decision-making in the real world.

2.1. Phase 1: Development of the prioritisation criteria

For the consumer panel (n = 7), we recruited a diverse group of highly experienced and committed consumer leaders with established health issues literacy and the ability to advocate professionally. Consumers were identified through advocacy groups, hospitals, and university networks. Interested individuals completed questionnaires followed by structured interviews to further explore their potential to contribute.

Each of the three clinician panels were comprised of nine medical oncologists: seven Australians familiar with the local reimbursement system, and two oncologists from other countries to provide a global perspective [12–14]. Participation was by invitation only and based on clinical experience in the cancer of interest and recognition as a key opinion leader. Participants were blinded to other participants to minimise discussion outside of the Delphi process [15].

The prioritisation criteria were chosen to reflect reimbursement considerations by PBAC. Consumers were provided with background reading and the proposed criteria prior to a face-to-face 90-minute workshop on July 13th, 2021. During the workshop, there were facilitated group discussion and ranking exercises. Consumers had the opportunity to review the proposed HS method and provide feedback to improve the person-centred approach. Input obtained during the workshop was incorporated into the final design of the HS method.

AHP was used to elicit weights of relative importance [11]. This method, using pairwise comparisons, was selected due to its moderate resource requirement and risk of bias [16]. The AHP was performed

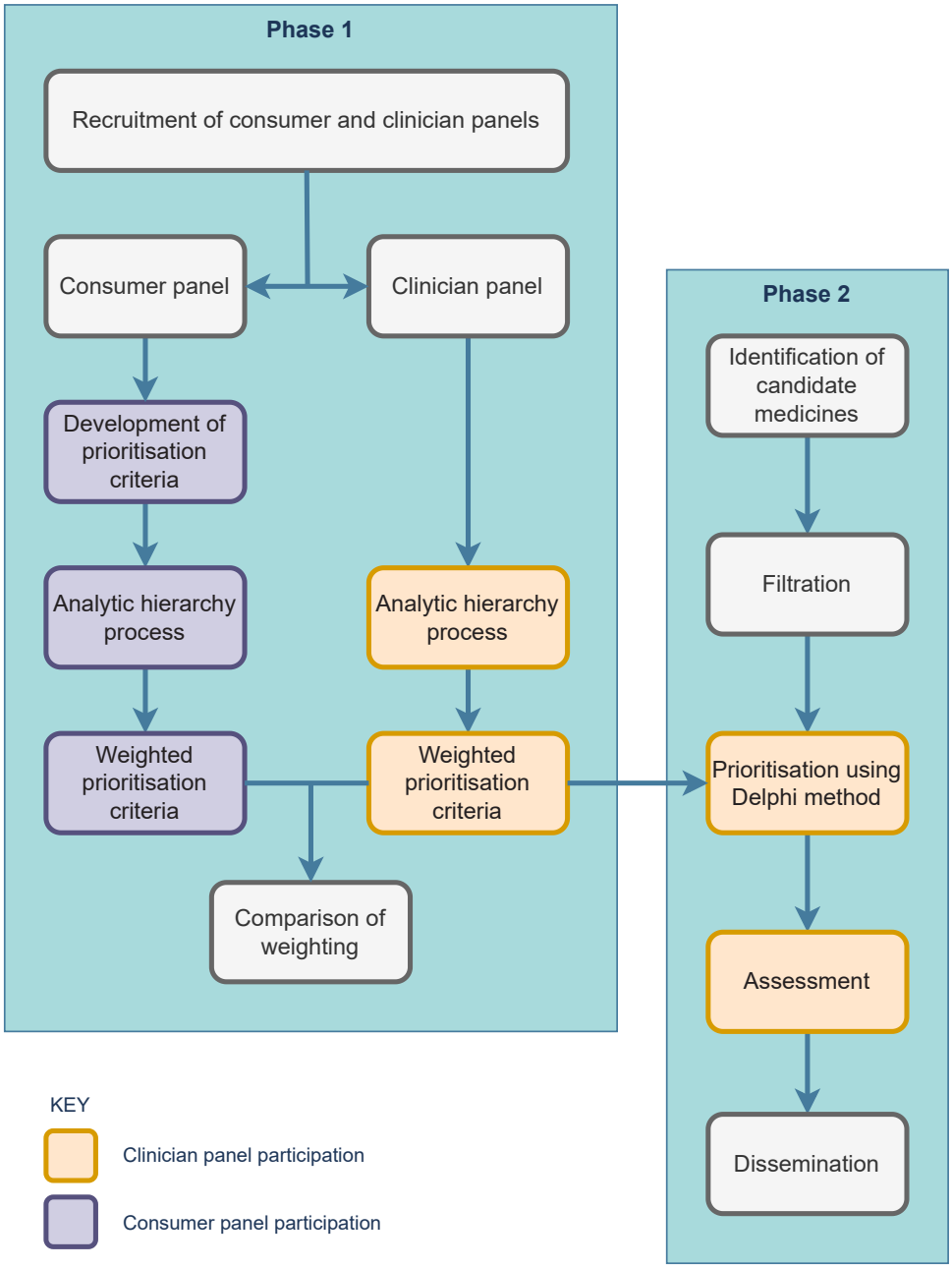

Fig. 1. Overview of horizon scan methodology.

twice by the consumers and clinicians: first adopting a curative then a non-curative intent perspective. The consumer panel completed the AHP using paper surveys (Supplementary Appendix S1) during the workshop. However due to COVID-19 and scheduling restraints, the AHP by clinicians was completed online using a Qualtrics survey (Supplementary Appendix S2).

2.2. Phase 2: Selecting and ranking new therapies (horizon scan)

2.2.1. Identification and filtration

Identification and filtration of medicines was completed by three lead investigators (MA, JS, YT). To promote efficiency, we chose the exhaustive ClinicalTrials.gov database [17] to leverage native in-built filtration methods allowing lists of medicines to be produced and updated quickly. Results were limited to interventional trials in phase two or three of development with a primary completion date between 1st January 2018–31 st December 2022 under the assumption that agents in earlier phase trials or trials with a primary completion date after this time were unlikely to proceed through Australia's regulatory and reimbursement process before December 2025. We further excluded paediatric trials and those enroling fewer than 100 participants (or 150 in NSCLC due to the larger number of trials). Data extraction occurred on April 8th, 2021. Manual review by the lead investigators censored therapies that had existing PBS listings for the same indication, duplications and studies primarily examining the effects of non-pharmacological interventions. To minimise inadvertent omissions, the list was cross-referenced with a secondary source: MAESTrO, a database of global market access submissions [18], and a tertiary source: the Dutch National Health Institute's horizon scans [19]. In addition, clinicians were asked to nominate promising medicines with special consideration of rare cancers.

2.2.2. Prioritisation

Prioritisation was informed by clinician panels using an online modified Delphi methodology [12,15,20–22]. Given the Delphi questionnaire was structured, it was determined that three iterative rounds would be sufficient to reach consensus [23–26]. Participants were given two weeks to respond to each round, with a one-week turnaround for interim analysis.

In round one, clinicians reviewed the filtered list of candidate medicines corresponding to their cancer of expertise. They were asked to nominate the 15 therapies most likely to impact the Australian healthcare system by 2025. An Excel spreadsheet served as the response form and included information on each medicine's clinical indication, sponsor, clinical trial phase and size, primary outcome measures and recruitment status. In round two, clinicians were able to review aggregated results from round one and refine their selection to ten medicines, which were progressed to the final round.

A Qualtrics survey was built for round 3, where clinicians were asked to score how likely a medicine was to achieve the prioritisation criteria (Supplementary Appendix S3). We employed a six-point Likert scale to optimise the reliability of responses [27]. Scores were then aggregated to identify the top five therapies for each cancer most likely to impact the Australian healthcare system in the next five years.

2.2.3. Assessment and dissemination

An overview of the top five therapies was produced using an assessment template (Supplementary Table S2), which included treatment indication, mode of administration, reimbursement status, key published evidence, and impact predictions. Estimates of uptake were also obtained from clinicians and reported as a percentage of eligible patients. Following completion of the HS, outputs were validated through periodic cross-referencing with publicly available PBAC meeting outcomes and public summary documents.

2.3. Statistical analyses

The AHP was performed manually and then validated using the *AHP Survey* package in RStudio version 2022.02.3 "Prairie Trillium". Consistency ratios (CR), a measure of the consistency of an individual's answers, were calculated for each participant and aggregated using the geometric mean. Lower CR values indicate more consistent answers with a typical threshold of < 0.10 [11]. However, given the complexity of the pairwise comparisons, a CR of < 0.25 was targeted. Weightings varied slightly between cancer types however sensitivity analyses exploring the impact of these differences showed no change in outputs. Consequently, the geometric mean was used to aggregate clinicians' scores across all cancer types resulting in the final criteria weights. The geometric mean was used to improve consistency and minimise the risk of rank reversal [28,29].

In round 3 of the Delphi process, the Likert scale was converted to numbers ranging from one ("extremely unlikely") to six ("extremely likely"). For each medicine, the arithmetic mean scores of the criteria were calculated and then relative weights elicited from the AHP were applied. Scores were then normalised and summed for a total out of 100 for each medicine.

Descriptive statistics and interquartile ranges (IQR) were used to summarise the criteria weightings and CRs. Estimates of uptake were reported as the arithmetic mean with IQR.

3. Results

3.1. Prioritisation criteria

Five proposed prioritisation criteria were reviewed in the consumer workshop, with consumers recommending a sixth criterion covering the aspect of unmet need (Table 1).

3.2. Analytic hierarchy process

The AHP was completed by both consumers and clinicians from a curative and non-curative treatment perspective in response to consumer panel opinion that priorities would change significantly depending on the treatment context (Fig. 2). The consumers and clinicians had a response rate of 100 % and 93 % respectively. The aggregated CR for the clinician curative weightings was 0.26 (IQR 0.31), with 44 % of clinicians achieving a CR of < 0.25. Non-curative weightings were more consistent with an aggregated CR of 0.14 (IQR 0.11) and 80 % of clinicians achieving a CR of < 0.25.

3.3. Identification and filtration of candidate medicines

Filtration by pre-set criteria reduced the lists substantially, which facilitated timely manual filtration (Supplementary Fig. S1). The NSCLC search was performed first, and following review, completion date parameters were further refined and used for subsequent searches. The final number of candidate medicines identified was 183 in NSCLC, 83 in

Table 1
Prioritisation criteria and definitions.

	Criteria	Definition
1	Toxicity	The likelihood of the medicine causing significant toxicity
2	Cost	The likelihood of the medicine resulting in cost savings to the Australian healthcare system
3	Quality of life (QoL)	The likelihood of the therapy improving a consumer's QoL
4	Survival	The survival benefit associated with the therapy compared to standard of care
5	Evidence	The strength of evidence supporting the benefits of the new medicine
6	Unmet need	The likelihood of the therapy meeting an unmet need

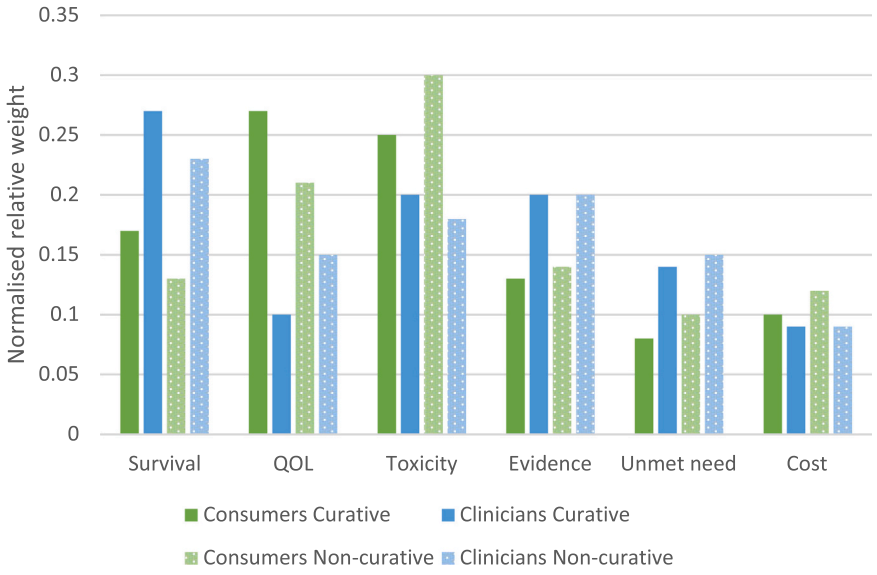

Fig. 2. Weighting of prioritisation criteria by AHP.

melanoma and 73 in CRC.

3.4. Prioritisation (Delphi surveys)

The Delphi process was completed in eight weeks and had a response rate of 100 %. Following round two, ten candidate medicines were shortlisted in NSCLC, eleven in melanoma, and twelve in CRC (Supplementary Table S3). After round three, the top five scoring medicines in each cancer type were exclusively high-cost drugs such as anti-body drug conjugates, immunotherapies, and targeted therapies.

As of March 2023, excluding biosimilars, there have been ten medicines treating CRC, NSCLC, or melanoma submitted for PBAC assessment. 70 % of these medicines were shortlisted by the HS as likely to impact the Australian healthcare system by December 2025. Of the five medicines that have received positive PBAC recommendations, the HS has identified three (Table 2). A tumour-agnostic PBAC submission for larotrectinib, relevant for melanoma and NSCLC was unsuccessful in March 2022. Two PBAC-recommended medicines not identified by the HS were cemiplimab and tepotinib (*MET*-inhibitor) for advanced NSCLC. An alternate *MET*-inhibitor, capmatinib, was identified instead. The HS did not identify regorafenib in CRC as a promising candidate: this agent has been assessed by PBAC but not recommended and future approval seems unlikely given its modest efficacy and significant toxicity.

3.5. Differences in consumer versus clinician weighting of prioritisation criteria

Toxicity and QoL were ranked the highest aggregated priorities for consumers with a mean normalised weighting of 0.24 for QoL and 0.28 for toxicity (Fig. 3). In the curative setting consumers favoured QoL over toxicity and the reverse in the non-curative setting (Fig. 2). For clinicians, survival remained the priority regardless of treatment intent. QoL and toxicity were lower priorities, accounting for 32 % of the total weighting compared to 52 % for consumers.

At the threshold of CR < 0.25, in the curative setting 57 % of consumers were consistent compared to 71 % in the non-curative setting. For clinicians 44 % versus 80 % were consistent in the curative and non-curative settings respectively. At the lower threshold of CR < 0.15, only 28 % of clinicians and 29 % of consumers were consistent in the curative setting. There was more variance in the non-curative setting with 52 % of clinicians and only 14 % of consumers achieving a CR < 0.15.

4. Discussion

This study has demonstrated that an agile and tailorable HS approach combining AHP and Delphi surveys is feasible. HS provides lead time to prioritise and clarify the burden of evidence required for successful submissions, leading to streamlining of the application process and improved transparency for all stakeholders. Furthermore, HS may allow HTA groups to adopt a more strategic approach to approvals that examines the implications of novel medicines in the context of existing and pipeline therapies. This will be of increasing importance as pipeline medicines are almost exclusively high cost and the financial sustainability of healthcare is under increasing scrutiny.

Early detection of complex medicines creates an opportunity to prepare and invest in infrastructure to facilitate rapid uptake upon approval. The widespread implementation of T cell therapies, for example, will require specialised laboratory processing and upskilling of clinicians. Another example is the new indication of adjuvant immunotherapy for resected stage II melanoma. In one Australian state, stage III and IV disease accounted for 9.4 % of new melanoma diagnoses whilst stage II disease accounted for 17.5 % [30]. If immunotherapy was approved for stage II disease, this would increase the eligible population for treatment and would have significant operational implications for day therapy centres, clinicians, pharmacists, and nurses.

To facilitate periodic updates to keep the HS relevant, we leveraged native database search functions for efficient filtration of candidate medicines. However, the exclusion of trials with fewer than 100 (or 150 in NSCLC) participants was a crude measure to identify medicines that were more advanced in the drug development phase. This risked omitting smaller but important trials for rare cancers, which was mitigated by cross-referencing with other sources and expert input. The omission of cost-minimising approvals such as for cemiplimab and bevacizumab (biosimilar) from the final HS list highlights a limitation of this method, which should be taken into account for future iterations. Coordinated efforts by the International Horizon Scanning Initiative are underway to improve collaboration and streamline multi-national HS approaches. Whilst benefit exists from pooling resources, care is required to ensure larger-scale processes do not become unwieldy and that outputs remain relevant for each country's unique regulatory environments.

There is growing recognition of the importance of consumers as active participants in the regulatory process, and our agile approach allowed the incorporation of consumer feedback and perspectives. Stakeholder input in the development of prioritisation criteria and

Table 2
HS results showing top five therapies in each cancer type and validation based on PBAC status.

	PBAC status	Shortlisted on HS	Not shortlisted on HS
CRC	Recommended	**Encorafenib and cetuximab** in advanced *BRAF*^{V600E} mutant disease	Nil relevant
	Deferred or rejected	**Larotrectinib*** for *NTRK*-fusion positive pre-treated advanced solid tumours	**Regorafenib** for previously treated advanced CRC not eligible for other therapies
	Not yet submitted	**Pembrolizumab** for MSI-H or dMMR previously treated disease **Trastuzumab deruxtecan*** for previously treated *HER2* positive advanced solid tumours **Tucatinib and trastuzumab** for previously treated *HER2* positive advanced disease	N/A
Melanoma	Recommended	Nil relevant	Nil relevant
	Deferred or rejected	**Relatlimab and nivolumab** for first-line unresectable disease	Nil relevant
	Not yet submitted	**Ipilimumab and nivolumab** as neoadjuvant therapy for resectable stage III disease **Pembrolizumab** as adjuvant therapy for resected stage II disease **Nivolumab** as adjuvant therapy for resected stage II disease **Entrectinib*** for advanced cancer with *NTRK, ROS1* or *ALK* gene fusion	N/A
NSCLC	Recommended	**Atezolizumab** in PD-L1 positive resected early-stage disease following adjuvant chemotherapy **Lorlatinib** for first-line unresectable disease	**Cemiplimab** in first-line PD-L1 > 50% positive advanced disease **Tepotinib** for *MET* ex14sk advanced disease
	Deferred or rejected	**Sotorasib** for *KRAS*^{G12C} positive previously treated advanced disease	**Mobocertinib**ˆ for previously treated *EGFR* ex20ins positive advanced disease
	Not yet submitted	**Selpercatinib** for *RET*-fusion positive advanced disease **Capmatinib** for *MET* exon 14-mutated or *MET*-amplified advanced disease	N/A

NB. During the validation period, a **bevacizumab*** biosimilar received a positive PBAC recommendation for an unrestricted listing.
* Tumour agnostic
ˆ Shortlisted in the top ten medicines for NSCLC at the end of the second round of Delphi surveys
5-FU: fluorouracil
BRAF^{V600E}: B-Raf proto-oncogene with an activating missense mutation in codon 600 of exon 15 dMMR: mismatch repair deficiency
EGFR ex20ins: epidermal growth factor receptor gene exon 20 insertion *HER2*: human epidermal growth factor receptor 2
KRAS^{G12C}: Kirsten rat sarcoma virus G12C mutation
MET, *MET* ex14sk: mesenchymal-epithelial transition factor, exon 14 skipping mutation
MSI-H: microsatellite instability high
N/A: not applicable
NTRK: neurotrophic tropomyosin-receptor kinase
PD-L1: programmed-death ligand 1
RET: rearranged during transfection gene

elicitation of relative weights resulted in a HS that was tailored to their specific needs. Reimbursement considerations are not uniform across diseases and populations, and our method lends itself to the incorporation of value-based prioritisation criteria. This may be increasingly relevant as HTA moves away from pure cost-effectiveness analyses and towards the integration of the value-based care.

The importance of the consumer voice was further highlighted by the discordant treatment priorities between consumers and clinicians, which is consistent with the literature [31–36]. Regardless of treatment intent, consumers ranked both toxicity and QoL over survival as the highest priorities. For clinicians, gains in survival were the clear priority. Value frameworks such as the European Society of Medical Oncology's Magnitude of Clinical Benefit Scale [37] and American Society of Clinical Oncology's Value Framework [38], which reduce QoL and toxicity considerations to unweighted points, may benefit from integrating MCDA to better reflect the nuances of patients' priorities. It is difficult to draw further conclusions about consumer preferences due to the size and composition of our panel, which may bias towards those who were well enough to participate. Care must also be taken when interpreting these results as only 61% of the AHP results had CR of < 0.25.

5. Conclusion

HS is of global importance given the rising cost of cancer care and increasing awareness of avoiding financial toxicity while maximising improvement in the outcomes that matter to people with cancer. The extent to which regulatory and reimbursement advisory groups have an obligation to consider HS varies from nation to nation. Reimbursement decisions should consider the benefits novel therapies hold based on both standard meaningful clinical trial endpoints as well as the endpoints that are important to patients and consumers, parameters which are not necessarily aligned. Our example provides a reproducible blueprint for adaptation to other healthcare settings that is responsive to consumer input and reflective of their priorities.

Ethics

This study reported on medicines of interest and involved the elicitation of expert opinion of consumers and clinicians. The consumer panel was recruited as an independent advisory group under the auspices of the PRIMCAT study and were asked to provide their expert opinion on reimbursement priorities for consumers in general in the context of a professional consultation. No demographic or sensitive data were collected. Therefore, as a negligible risk study, it was deemed exempt from ethics approval. Participation in this study was entirely voluntary with the opportunity to decline participation without consequence.

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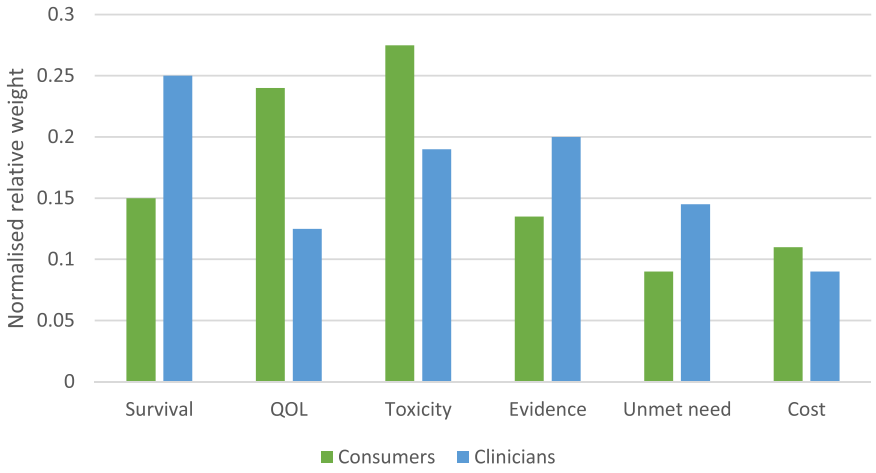

Fig. 3. Aggregated criteria weightings elicited by AHP.

Declaration of Competing Interest

MA has received financial support to attend conferences and meetings by AstraZeneca and serves on the advisory board for Pfizer and Bristol Myers Squibb.

PAA has/had a consultant/advisory role for Bristol Myers Squibb, Roche-Genentech, Merck Sharp & Dohme, Novartis, Merck Serono, Pierre-Fabre, AstraZeneca, Sun Pharma, Canofi, Idera, Sandoz, Immunocore, 4SC, Italfarmaco, Nektar, Boehringer-Ingelheim, Eisai, Regeneron, Daiichi Sankyo, Pfizer, Oncosec, Nouscom, Lunaphore, Seagen, iTeos, Medicenna, Bio-Al Health, ValoTX, Replimmune. He has received research funding grants from Bristol Myers Squibb, Roche-Genentech, Pfizer, Sanofi. He has received travel support from Pfizer.

SA has served uncompensated on the boards of Health Issues Centre, Australia, Victorian Agency for Health Information, and Safer Care Victoria.

MPB has received honoraria from BNS Australia, USD Oncology, and Novartis. He holds an advisory role for Bristol Myers Squibb, Merck Sharp & Dohme, Novartis, and Cartherics for which his institution receives reimbursements. His institution has also received reimbursement for research support from Bristol Myers Squibb, Merck Sharp & Dohme, Pharmaust, Zucero Therapeutics, and CStone Pharmaceuticals.

MB has received compensation and research support as an advisor and consultant to Pierre Fabre, MSD, GSK, Servier, and AstraZeneca.

MI is on the advisory boards of Pfizer, Roche, Takeda, BeiGene, Amgen, Merck, and MSD and has received honoraria from Pfizer, Roche, Takeda, Novartis, as well as research funding from Pfizer.

TJ reports consulting fees from AstraZeneca and MSD, and advisory boards and committees for AstraZeneca, Amgen, Bristol Myers Squibb, Merck & Co., MSD, Gilead, Puma, Pfizer Inc., Roche AG, Specialised Therapeutics, and Takeda Pharmaceutical, outside the submitted work.

SK reports honoraria to institution from Astra Zeneca, Roche, Pfizer, Bristol Myers Squibb, MSD and Takeda; consulting fees from AstraZeneca, Pfizer, MSD, Novartis, Roche, Takeda, Amgen; and research funding to institution from Astra Zeneca.

MK reports institutional grants from Nordic Farma, Merck-Serono, Pierre Fabre, Servier, Bayer, Bristol Myers Squibb, Merck, and Roche; and consulting fees and honoraria paid to institution from Pierre Fabre and Servier.

BTL has served as an uncompensated advisor and consultant to Amgen, AstraZeneca, Boehringer Ingelheim, Bolt Biotherapeutics, Daiichi Sankyo, Genentech, and Lilly. He has received research grants to his institution from Amgen, AstraZeneca, Bolt Biotherapeutics, Daiichi Sankyo, Genentech, Hengrui USA, and Lilly. He has received academic travel support from Amgen, Jiangsu Hengrui Medicine and MORE Health. He is an inventor on two institutional patents at MSK (US62/685,057, US62/514,661) and has intellectual property rights as a book author at Karger Publishers and Shanghai Jiao Tong University Press. BTL is supported by the Memorial Sloan Kettering Cancer Centre Support Grant P30 CA008748 and Research Project Grant R01CA249666 from the National Institutes of Health.

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BM is on the advisory boards of Amgen, MSD, Bristol Myers Squibb, Beigene and AstraZeneca.

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TMP has received research support from Roche and Pfizer, and holds a consulting or advisory role for Merck, Bristol Myers Squibb, Novartis, Sanofi/Regeneron, and Pfizer.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jcpo.2023.100441.

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