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Defining and Validating Criteria to Identify Populations Who May Benefit From Home-Based Primary Care

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Background: Home-based primary care (HBPC) is an important care delivery model for high-need older adults. Currently, target patient populations vary across HBPC programs, hindering expansion and large-scale evaluation.

Objectives: Develop and validate criteria that identify appropriate HBPC target populations.

Research Design: A modified Delphi process was used to achieve expert consensus on criteria for identifying HBPC target populations. All criteria were defined and validated using linked data from Medicare claims and the National Health and Aging Trends Study (NHATS) (cohort n = 21,727). Construct validation involved assessing demographics and health outcomes/expenditures for selected criteria.

Subjects: Delphi panelists (n = 29) represented diverse professional perspectives. Criteria were validated on community-dwelling Medicare beneficiaries (age ≥ 70) enrolled in NHATS.

Measures: Criteria were selected via Delphi questionnaires. For construct validation, sociodemographic characteristics of Medicare beneficiaries were self-reported in NHATS, and annual health care expenditures and mortality were obtained via linked Medicare claims.

Results: Panelists proposed an algorithm of criteria for HBPC target populations that included indicators for serious illness, functional impairment, and social isolation. The algorithm's Delphi-selected criteria applied to 16.8% of Medicare beneficiaries. These HBPC target populations had higher annual health care costs [Med (IQR): $10,851 (3316, 31,556) vs. $2830 (913, 9574)] and higher 12-month mortality [15% (95% CI: 14, 17) vs. 5% (95% CI: 4, 5)] compared with the total validation cohort.

Conclusions: We developed and validated an algorithm to define target populations for HBPC, which suggests a need for increased HBPC availability. By enabling objective identification of unmet demands for HBPC access or resources, this algorithm can foster robust evaluation and equitable expansion of HBPC.

Key Words: home-based primary care, serious illness, health care access, equity

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BACKGROUND

Home-based primary care (HBPC) refers to longitudinal primary care delivered in the home setting by billable HBPC clinicians (ie, M.D., D.O., P.A., and N.P.).[1] Though distinct from other types of home-based services (eg, skilled home health or home-based palliative care), HBPC often includes multidisciplinary team care and occurs in coordination with other in-home services. For persons with medical or social complexity and access barriers, the HBPC model can serve as a substitute for office-based delivery.

Examples of patient populations who may benefit from HBPC include the growing numbers of older adults with multimorbidity, serious illness, functional impairments, and/or who have difficulty leaving the home. Often, these populations also have increased susceptibility to social vulnerabilities, such as transportation difficulties,

food insecurity, or social isolation.[2] The United States has experienced rapid growth in its homebound population; before 2020, the prevalence among community-dwelling older adults was ~6%, which then doubled during the COVID pandemic.[3,4]

These demographic trends have coincided with policies that could increase HBPC demand, such as the shift to value-based care and the push for deinstitutionalization through expanded home and community-based services.[5] Although the factors driving demand are well characterized, the exact level of HBPC need is not yet known, largely because there is no shared definition for the types of patients that could most benefit.[5] Without a clear and consistent conceptualization of HBPC target populations, health system leaders (eg, policy makers, payers, administrators, and investors) will encounter difficulties addressing HBPC workforce capacity, defining metrics of HBPC quality or equity, and conducting robust evaluations of HBPC effects.

HBPC is associated with reduced emergency department visits, hospital admissions, skilled nursing facility placements, and inpatient lengths of stay.[6–11] Studies have also demonstrated cost savings, especially among the most frail recipients.[8,12–14] In qualitative interviews, patients and caregivers have perceived HBPC to improve quality through better access, continuity, and patient education.[12,15] These perspectives are corroborated by improved rates of documented goals of care conversations, follow-up contacts, and medication reconciliations.[12,13,16]

Though promising, an important shortcoming of these findings is that few studies have been able to make causal claims about HBPC's effects.[17] Evaluations have been limited in scale and scope in part because of variations in HBPC target populations.[10,17] For instance, the "Independence at Home" (IAH) demonstration program through the Center for Medicare and Medicaid Innovation (CMMI) used markers for complex, costly care plus functional impairments to determine HBPC eligibility,[13,16] whereas the Veterans Health Administration targeted a much broader population.[18] Other hospital systems have piloted smaller-scale HBPC programs that similarly applied their own eligibility criteria.[6,8,9,11,19]

Robust analyses of HBPC effects on care quality and outcomes for specific populations are necessary to support investment in its expansion.[10] Despite the observed benefits for seriously ill populations, HBPC continues to be under-resourced and underutilized, with significant geographic differences in access.[20] For example, in 2019, the number of home-based visits per 1000 Medicare fee-for service (FFS) beneficiaries by state ranged from <23 (eg, South Dakota, Alaska, Vermont) to >265 (eg, North Carolina, Nevada, and Michigan).[20] Trends across 2012–2019 showed that although the amount of care delivered in homes has increased, this growth was mostly driven by visits in domiciliary settings, ie, group homes, boarding homes, and assisted living facilities, rather than private homes.[20] It remains unclear whether HBPC disparities exist along sociodemographic or clinical gradients, since, to date, there is no uniform conceptualization of target populations that may benefit from HBPC.

The goal of this study was to: (1) generate a consensus definition of target populations that may benefit from HBPC according to social and/or medical vulnerabilities; and (2) validate the appropriateness of this consensus definition.

METHODS

This study applied a 4-step modified Delphi process (MDP) followed by a construct validation process spanning from January to May of 2023 to define patient populations that may benefit from HBPC. MDP is an established method for obtaining structured input from content experts, especially when consensus is needed, or there are persistent gaps in the literature.[21–24] The original Delphi method elicits anonymous, iterative feedback from experts (as defined by study teams) and synthesizes their opinions.[21] Common modifications to this method have included platforms for Delphi panelists to interact directly, which may strengthen group decision-making in clinical guideline formation.[21,22,24–27]

Modified Delphi Process Panelist Selection

Although content validity can be achieved with as little as 10 experts, 64 US experts were invited to participate in the MDP with the goal of enrolling 20–30 panelists representing a range of perspectives.[28] Purposive sampling of the study team's broad professional network sought diversity in terms of sociodemographic traits and professional factors (ie, private vs. public sector affiliation; medical specialty and home-based vs. office-based practice setting; involvement in financial, social, clinical, or administrative roles).

Initial Criteria and Data Sources

Supplemental Table 1s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904 contains criteria that were evaluated by MDP panelists. The initial list of potential criteria for defining HBPC target populations was informed by the study team's collective clinical experiences, a literature review, and the availability of patient-level variables.[29,30]

Two linked data sources were used to create the initial list of criteria and, in the construct validation stage, were then used to assess the appropriateness of criteria selected by the MDP: Medicare fee-for-service (FFS) claims and the 2011–2017 waves of the National Health and Aging Trends Study (NHATS). NHATS surveys a nationally representative sample of older Medicare beneficiaries.[31] Interviews were conducted annually in person. In addition to detailed self-reports of physical function, chronic health conditions, and socioeconomic factors, NHATS included formal physical and cognitive assessments. To ensure stability in diagnostic codes and to allow for survey weighting, this study focused on community-dwelling NHATS participants with ≥ 12 consecutive months of FFS Medicare enrollment and age ≥ 70 (since NHATS is replenished every 5 y) (Supplemental

Fig. 1s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904).

Modified Delphi Process Stages

Figure 1 summarizes the MDP, which solicited iterative feedback from expert professionals via RedCap questionnaires plus a focus group discussion. (See Supplemental eMethods 1, 2, and 3, Supplemental Digital Content 1, http://links.lww.com/MLR/C904 for questionnaire format.) Questionnaires asked Delphi panelists how beneficial HBPC would be for patients with certain medical and/or social vulnerabilities, henceforth "HBPC criteria." Each HBPC criterion was assessed using a 5-point Likert scale, plus open-ended response options. Consensus to advance or exclude criteria was defined as $\geq 70\%$ votes for "very/extremely" or "unlikely/not at all" beneficial, respectively. (In MDPs, the chosen thresholds for defining content validity have varied depending on context.[24,32] For instance, Keddem et al[32] used 50% when creating a patient engagement toolkit, whereas Eubank et al[24] used 80% in defining diagnostic/treatment criteria of rotator cuff pathology. For defining HBPC target populations, 70% panelist agreement was deemed adequate.)

MDP stage 2 consisted of a questionnaire that applied the same format and threshold to assess remaining and newly added HBPC criteria. This questionnaire additionally presented aggregated results from the prior stage and asked panelists to rank the 5 best criteria and select up to 5 other criteria for elimination.

For MDP stage 3, the study team hosted a virtual focus group with available panelists to continue refining the criteria for defining HBPC target populations. In preparation for this 45-minute session, panelists received a spreadsheet of aggregated questionnaire results (Supplemental Table 2s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904) and preliminary analyses for the FFS Medicare beneficiaries meeting each criterion under consideration (Supplemental Table 3s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904). These preliminary analyses included the number and weighted percent of FFS beneficiaries along with categories of sex, age, race, ethnicity, and marital status; mean (SD) income; and mean (SD) mortality rate.

In MDP stage 4, panelists received an email sharing major themes and recommendations from the focus group. The email invited feedback and included a RedCap poll to clarify panelists' views about one criterion (Supplemental eMethods 3, Supplemental Digital Content 1, http://links.lww.com/MLR/C904).

Criteria Validation Process

Finally, the study team validated the appropriateness of criteria by characterizing HBPC target populations using real-world data. Construct validation used a cohort of community-dwelling NHATS participants with FFS Medicare (n = 21,727) to characterize the sociodemographic traits, Medicare expenditures, health care utilization, and 12-month mortality rates for the total study cohort and for the HBPC target patient populations. Analyses were conducted in RStudio 2021.09.2 and Stata 16.0, and applied survey weights to ensure the study population was representative of the Medicare population.

NHATS self-reported responses, NHATS physical/cognitive assessments, and ICD-9/ICD-10 codes were used to create groups of HBPC target populations as defined by chosen criteria (Supplemental Table 1s, 5s, 6s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904 for criteria definitions and ICD codes). Using weighted frequencies, an UpSet plot was created to depict

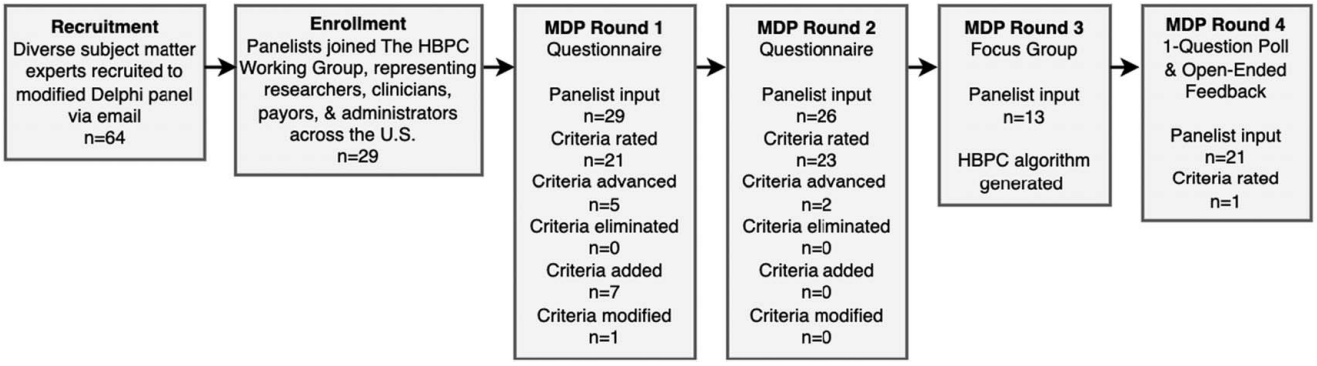

FIGURE 1. MDP to define criteria for HBPC. Subject matter experts were invited to join the HBPC Working Group and serve as panelists in an MDP focused on establishing criteria to define HBPC target populations. The study team created an initial list of criteria for consideration, and the MDP, consisting of 4 rounds, allowed for modifications to this list. MDP rounds 1 and 2 were online RedCap questionnaires. Panelists rated how beneficial HBPC would be for patients meeting each of the potential criteria using a 5-point Likert scale. Consensus to advance or exclude criteria was defined as $\geq 70\%$ votes for "very/extremely" or "unlikely/not at all" beneficial, respectively. Criteria could be modified, added, or combined via open-ended response. MDP round 3 was a virtual video conference focus group with a subset of panelists, based on their availability. The focus group discussion yielded an algorithmic approach to organizing criteria for identifying HBPC target populations. MDP round 4 summarized the focus group discussion for all panelists, including the resultant algorithm, and conducted a brief RedCap poll to obtain panelist feedback on the algorithm's structure. HBPC indicates home-based primary care; MDP, modified Delphi process.

the most common phenotypes of social and medical vulnerability that warrant consideration for HBPC. The plot presented each HBPC target population with horizontal bars and unique combinations of overlap with vertical bars.

Age, sex, race, ethnicity, education, marital status, annual household income, and metropolitan status were assigned based on NHATS responses. Race and ethnicity categories could not be separated due to unreportable sample sizes. Hispanic ethnicity was combined with other race/ethnicity categories that were too small to report.

Analyses reported median (IQR) annual Medicare expenditures (adjusted for inflation) and 12-month mortality rates, the latter of which was captured through both NHATS and Medicare files.

The Massachusetts General Brigham IRB deemed this study exempt from human subjects research.

RESULTS

Figure 1 summarizes results from each MDP round, including panelist participation/retention and criteria advancement/elimination.

Modified Delphi Process Panelists

Collectively, MDP panelists (n = 29) had expertise in internal medicine, geriatrics, palliative care, home-based medical care, health care administration, health services research, health system reform, and health care finance. (See Supplemental Table 7s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904 for panelist characteristics.)

Modified Delphi Process Rounds 1 and 2: Online Questionnaires

All 29 panelists completed round 1 of the online survey. None of the criteria met the threshold for exclusion, and 5 met the threshold for advancement. On the basis of panelists' open-response feedback, one criterion was modified to target a narrower population (use of either "Hoyer lift/hospital bed/home oxygen" became "Hoyer lift/hospital bed"), and several others were added, either as new recommendations ("hospice discharge," "stage IV pressure ulcer") or as combinations of previously suggested individual criteria (eg, combinations of "ADL impairments" or "serious illness" with "transportation disadvantage" or "semi-homebound") (Supplemental Table 1s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904).

The majority (26/29) of panelists completed the round 2 survey. No criteria were eliminated, modified, or added in this round. Two criteria met the threshold for advancement ("Hoyer lift/hospital bed," "serious illness + transportation barrier"). Supplemental Table 2s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904 summarizes aggregated survey responses.

Modified Delphi Process Rounds 3 and 4: Focus Group and Follow-Up Poll

A subset (n = 13) of MDP panelists participated in a virtual focus group, during which they emphasized a need for HBPC target populations to represent diverse socioeconomic groups with consistently high health care expenditures. Their discussion (further summarized in Supplemental Table 4s, Supplemental Digital Content 1, http://links.lww.com/MLR/C904) helped winnow the list of criteria still under consideration and culminated in an algorithmic arrangement of the criteria they ultimately chose to prioritize (henceforth "HBPC Algorithm") (Fig. 2). In MDP round 4, 21/29 panelists responded to the follow-up RedCap poll regarding inclusion of the stage IV pressure ulcer criterion. A majority (13/21) voted that this should be a stand-alone criterion in the proposed HBPC algorithm (vs. combined with ADL impairments or serious illness).

By the end of this round, there was consensus among experts that the newly constructed HBPC algorithm would be appropriate for defining populations that could benefit from HBPC. Panelists agreed that the HBPC algorithm would be sensitive enough to characterize patients with social vulnerabilities and medical complexity while also being specific enough to target reasonably sized populations. Several criteria in the algorithm were designated as stand-alone markers of potential HBPC need: persistent homebound status, moderate-to-severe dementia, live hospice discharge, IAH eligibility, and stage IV pressure ulcer. The algorithm also suggested HBPC could be beneficial for those with serious illness or ADL impairments, if they also had ≥ 1 of the following: transportation barrier, semi-homebound status, Hoyer lift or hospital bed use, and home health episode recertification.

VALIDATION OF CRITERIA IN THE HOME-BASED PRIMARY CARE ALGORITHM

Demographics

Table 1 presents demographic data grouped by HBPC criteria. The total validation cohort of community-dwelling Medicare FFS beneficiaries was 56% (95% CI: 55, 58) female, 84% (95% CI: 82, 86) White non-Hispanic, 7% (95% CI: 6,8) Black non-Hispanic, and 9% (95% CI: 8, 11) Hispanic/Other, with a median (IQR) annual household income of $36.8K (19.8K, 70.0K). Those who met ≥ 1 HBPC criterion were from households earning a median (IQR) annual income of $24K (13.2, 44.0). Females constituted a majority of each HBPC criterion [maximum 74% (95% CI: 65, 81) for serious illness + transportation barrier), with the exception of the serious illness + Hoyer lift/hospital bed criterion [49% (95% CI: 33, 65)]. Black non-Hispanic and Hispanic individuals were over-represented in nearly all HBPC criteria; the criterion for serious illness + Hoyer lift/hospital bed had among the highest proportions of Black beneficiaries [18% (95% CI: 13, 23)], and the ADL impairments + transportation barrier criterion had the largest proportion of Hispanic beneficiaries 20% (95% CI: 14, 28).

Of the total validation cohort, 16.8% met ≥ 1 HBPC criterion. The stage IV pressure ulcer criterion applied to the smallest portion of community-dwelling FFS beneficiaries [0.4% (95% CI: 0.3, 0.6)]. The moderate-to-severe

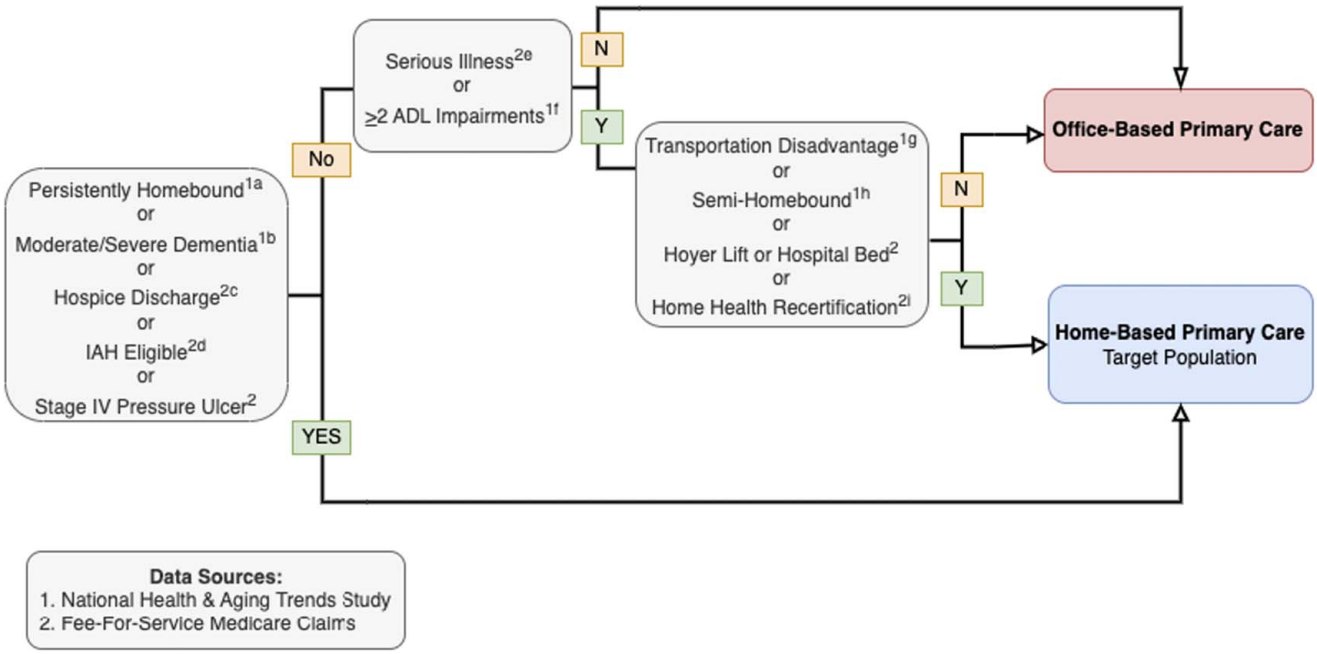

FIGURE 2. Algorithm of criteria for identifying HBPC target populations. Criteria were selected by a panel of experts in a modified Delphi process and are defined using (1) survey response data from the NHATS or (2) Medicare claims data with ICD codes. A, Left home ≤ 1 d/wk in the past month, reported on 2 consecutive (annual) surveys. B, Patient or proxy reported diagnosis; > 2 cognitive interview impairments and difficulty with > 1ADL[f] *and* > 1 instrumental ADL[f]; AD-8 score > 3. C, Patient remained alive > 6 months after hospice enrollment. D, "IAH" is an HBPC demonstration program through The Center for Medicare and Medicaid Innovation. Eligibility criteria are nonelective hospitalization and home health or skilled nursing facility use and > 2 chronic conditions (per the chronic conditions data warehouse) and > 2 ADL[f] impairments. E, > 1 of the following: metastatic or hematologic malignancy; end-stage renal disease; advanced liver disease; diabetes with severe complication; neurodegenerative disease; AIDS; hip fracture; dementia; chronic obstructive pulmonary disease, interstitial lung disease, or congestive heart failure requiring home oxygen, or hospitalization. F, Activities of daily living. G, Unable to participate in social activities in the past month due to a transportation issue. H, In the past month, did leave home > 1 d/wk but reported difficulty or required assistance. I, Required more than the allotted 60 days of home health under Medicare part A. HBPC indicates home-based primary care; ICD, International Classification of Disease; IAH, Independence at home; NHATS, National Health and Aging Trends Study.

dementia criterion [5.3% (95% CI: 4.8, 5.9)] and the serious illness + home health recertification criterion applied to the highest proportion of FFS beneficiaries [5.3% (95% CI: 4.8, 5.8)].

Mortality and Health Care Expenditures

Figure 3 shows that those meeting ≥ 1 HBPC criterion had higher health care costs and higher 12-month mortality rates compared with the total validation cohort. While the median (IQR) annual health care cost for all community-dwelling Medicare FFS beneficiaries was $2830 (913, 9574), HBPC target populations had annual health care costs ranging from $7222 (2633, 22,178) (serious illness + transportation barrier) to $24,221 (5333, 65,282) (serious illness + Hoyer lift/hospital bed). The 12-month mortality rate was 5% (95% CI: 4, 5) for the total validation cohort. In contrast, the 12-month mortality rate for HBPC target populations ranged from 7% (95% CI: 5, 9) among those meeting the serious illness + home health recertification criterion to 31% (95% CI: 27, 35) among the persistently homebound population.

Frequencies and Overlap

Using criteria from the HBPC algorithm, the UpSet plot in Figure 4 depicts how common it is for FFS beneficiaries to have overlapping social and medical vulnerabilities that could potentially be addressed by HBPC programs. The UpSet plot also illustrates the implications of excluding a target population, either by removing a criterion from the HBPC algorithm or by failing to capture data that define the target group. By way of example, persistent homebound status (leaving home ≤ 1 d/wk over 2 annual assessments) was only the fourth largest HBPC target population overall (weighted n = 4,449,000, representing 4.2% of all community-dwelling beneficiaries age ≥ 70), but it was the second most frequent phenotype of target populations (weighted n = 1,359,000, representing 1.2% of beneficiaries). The UpSet plot thus reveals that 30.5% (1,359,000/4,449,000) of persistently homebound individuals would have been missed by failing to measure homebound status or by omitting this criterion from the HBPC algorithm.

In a similar vein, Figure 4 demonstrates how health systems may use the HBPC algorithm as a dynamic tool;

TABLE 1. Demographics of HBPC Target Populations*

	Population Size n (% validation cohort)	Age median (IQR)	Female % (95% CI)	White, non-Hispanic†% (95% CI)	Black, non-Hispanic†% (95% CI)	Hispanic /Other†% (95% CI)	Median household income $1000/y (IQR)	Married/ Partnered‡% (95% CI)	Education ≥ some college % (95% CI)	Nonmetro % (95% CI)
Total validation cohort§	21,727 (100)	77 (77–83)	56 (55, 58)	84 (82, 86)	7 (6, 8)	9 (8, 11)	36.8 (19.8– 70.0)	53 (51, 54)	55 (53, 58)	21 (13, 30)
HBPC target populations, defined by HBPC criteria										
Total HBPC targets*	4474 (16.8)	82 (76–88)	62 (59, 65)	76 (73, 79)	10 (9, 12)	14 (11, 16)	24 (13.2–44)	39 (35, 42)	42 (39, 46)	19 (12, 29)
IAH eligible‖	908 (3.3)	84 (78–89)	67 (63, 71)	79 (74, 82)	10 (8, 12)	12 (8, 16)	23.2 (13.2–42.8)	36 (33, 41)	42 (37, 46)	17 (10, 27)
Persistently homebound¶	1112 (4.2)	86 (80–91)	72 (68, 76)	74 (69, 79)	10 (8, 12)	16 (12, 22)	21 (12–37.2)	29 (25, 34)	39 (33, 46)	20 (13, 31)
Mod-severe dementia#	1596 (5.3)	83 (79–89)	64 (59, 69)	73 (69, 77)	11 (9, 14)	16 (12, 20)	22 (12.3–42)	36 (32, 41)	38 (33, 44)	15 (9, 23)
Hospice discharge**	481 (1.7)	83 (76–88)	64 (52, 75)	83 (74, 89)	10 (7, 15)	7 (4, 15)	24.2 (14.2–41)	42 (33, 51)	36 (28, 45)	24 (13, 40)
Serious illness†† + transportation barrier‡‡	211 (0.8)	83 (77–89)	74 (65, 81)	74 (63, 82)	NR	NR	19.4 (12–32.4)	16 (11, 23)	31 (23, 39)	18 (10, 30)
ADL Impairments§§ + Transportation Barrier‡‡	425 (1.5)	79 (75–85)	69 (60, 78)	69 (61, 76)	11 (7, 15)	20 (14, 28)	20.4 (11.6–35.6)	32 (26, 38)	43 (36, 51)	17 (9, 29)
Serious illness†† + semi-homebound‖‖	503 (1.9)	82 (76–88)	61 (55, 66)	79 (73, 84)	11 (8, 15)	11 (7, 15)	26 (15–44)	39 (33, 45)	44 (38, 50)	23 (14, 36)
ADL impairments§§ + semi-homebound‖‖	1003 (3.7)	77 (74–82)	67 (62, 72)	75 (70, 79)	11 (8, 14)	15 (11, 20)	25 (13–45.6)	41 (35, 47)	43 (38, 48)	17 (10, 27)
Serious illness†† + Hoyer lift/hospital bed¶¶	117 (0.5)	85 (78–91)	49 (33, 65)	69 (53, 82)	NR	NR	20.7 (11–46)	42 (27, 59)	40 (25, 57)	NR
ADL impairments§§ + Hoyer lift/hospital Bed¶¶	591 (1.8)	79 (75–85)	63 (56, 70)	70 (63, 76)	18 (13, 23)	12 (8, 18)	20.7 (12.5–37.8)	41 (33, 49)	30 (24, 37)	16 (8, 29)
Serious illness†† + HH recertification##	1139 (4.8)	84 (78–89)	52 (46, 58)	76 (71, 81)	11 (8, 14)	13 (10, 57)	26 (15–45)	41 (35, 47)	45 (38, 52)	18 (11, 29)
ADL impairments§§ + HH recertification##	1496 (5.3)	80 (74–85)	67 (63, 72)	74 (69, 78)	11 (8, 14)	16 (12, 21)	23 (13–40.8)	33 (29, 37)	40 (35, 45)	17 (10, 28)
Stage IV pressure ulcer***	111 (0.4)	80 (74–85)	71 (49, 86)	NR	15 (7, 29)	NR	24.8 (17.3–45)	42 (24, 62)	43 (23, 67)	NR

In a modified Delphi process, a panel of experts selected criteria for defining HBPC target populations (ie, "HBPC criteria"). The NHATS was used to assign age, sex, race, ethnicity, education, marital status, annual household income, and metropolitan status. Numbers are unweighted; analyses apply survey weights. Some data are NR due to cell size restrictions.

*Meeting ≥1 HBPC criterion.

†Race and ethnicity categories could not be separated due to unreportable sample sizes. For this same reason, the Hispanic ethnicity category was combined with other race/ethnicity categories that were too small to report, including those with missing race/ethnicity data.

‡Other marital status categories included divorced, separated, widowed, never married, and missing marital status data.

§Construct validation of HBPC criteria was performed using NHATS linked to Medicare claims data. The total validation cohort consisted of community-dwelling Fee-for-Service Medicare beneficiaries age ≥70, representing 21,727 person-years of observation.

‖Eligibility for the Independence At Home (IAH) demonstration program through The Center for Medicare and Medicaid Innovation is based on the following parameters in claims data: nonelective hospitalization and home health or skilled nursing facility use and >2 chronic conditions (per the chronic conditions data warehouse) and dependent in >2 activities of daily living (ADL).

¶Reported on 2 consecutive (annual) NHATS surveys that the patient had left home ≤1 day/week in the past month.

#One of the following on NHATS: Patient or proxy reported diagnosis; > 2 cognitive interview impairments and difficulty with >1 ADL and >1 instrumental ADL; AD-8 score >3.

**Claims indication of hospice discharge because patient remained alive >6 months after hospice enrollment.

††ICD codes indicating >1 of the following: metastatic or hematologic malignancy; end-stage renal disease; advanced liver disease or cirrhosis; diabetes with severe complication; neurodegenerative disease; AIDS; hip fracture; dementia; COPD, interstitial lung disease, or congestive heart failure requiring home oxygen or hospitalization.

‡‡Unable to participate in social activities in the past month due to a transportation issue, per NHATS.

§§Impaired in ≥2 ADLs per NHATS.

‖‖In the past month, did leave home more than 1 d/wk but either reported difficulty or required assistance to do so, per NHATS.

¶¶ICD codes indicating the use of a Hoyer lift or hospital bed.

##Required more than the allotted 60 days of home health, as indicated by a recertification in Medicare claims.

***ICD codes indicating stage IV pressure ulcer. (Note this is a conservative estimate due to under-reporting in claims data.)

HBPC indicates home-based primary care; NHATS, National Health and Aging Trends Study; NR nonreportable.

if, for instance, they sought to prioritize patients with moderate-to-severe dementia [weighted n (%) = 6,229,000 (5.3%)] but wanted a smaller panel, then they may narrow their target population to those with moderate-to-severe dementia who are also persistently homebound.

DISCUSSION

Through a modified Delphi process, this study developed an algorithm for defining target populations that may benefit from HBPC using markers of medical and social complexity. Construct validation supported the appropriateness and relevance of the algorithm's criteria by demonstrating that HBPC target populations had higher health care costs and higher 12-month mortality rates compared with the total validation cohort of FFS beneficiaries. The results of this process can help HBPC practices, health systems, payers, and investors scale and evaluate HBPC while also prioritizing access for vulnerable subgroups.

In designing the algorithm, panelists were encouraged to consider actionable indicators of HBPC need, independent of present data availability in Medicare claims or electronic health records. Panelists uniformly noted that although there are many potential benefits of HBPC, from caregiver support to cost savings, care coordination, and enhanced recognition of social or environmental needs, the most fundamental benefit of HBPC is its capacity to improve care access. They therefore chose criteria that corresponded with a high risk of being homebound. Notably, the homebound criterion and several other key pieces of the HBPC algorithm (eg, transportation barriers) were derived from NHATS survey data and are characteristics not routinely captured in administrative data. This underscores a need for health systems to improve, standardize, and incentivize documentation of characteristics such as the difficulty and frequency at which patients leave their homes or other disability measures not routinely captured in health records or charted using ICD-10 Z-codes.[33,34]

Panelists' emphasis on homebound status stems from a desire to promote equitable care access for those who face difficulty getting to clinic-based appointments and from the known negative outcomes associated with being homebound. Prior literature has shown that homebound individuals report high symptom burden,[35] experience more functional impairments and chronic medical conditions,[3] and have higher rates of hospitalization[3] and mortality[36,37] compared with those who leave home without help or difficulty. Earlier evaluations of NHATS data have demonstrated that homebound individuals are more likely to be female, non-White race, in lower income groups, and have lower educational attainment and more chronic conditions compared to non-homebound individuals.[3,4] This study's proposed algorithm for HBPC target populations included an array of conditions associated with increased risk of being homebound, such as experiencing transportation barriers, having a stage IV pressure ulcer, or carrying a diagnosis of moderate-to-severe dementia. In doing so, the algorithm similarly captured disproportionately high numbers of racially minoritized and socially vulnerable groups.

The appropriateness of criteria in the HBPC algorithm was further evident in its inclusion of individuals with complex morbidity, high mortality rates, and elevated health care costs. Notably, the HBPC algorithm applies to a meaningful portion of community-dwelling FFS beneficiaries (16.8%), and this percentage is expected to rise with the aging population and the systems-level shift from institution-based to community-based long-term services and supports. To date, FFS Medicare has lagged behind Medicare Advantage plans in terms of the fraction of beneficiaries receiving any home-based care.[38,39] Previous analyses of NHATS data linked with Medicare claims found that only 5% of the total FFS population and only 11% of the homebound population had received any amount or type of billable medical care in the home between 2011 and 2017.[40] Among FFS Medicare beneficiaries, both delivery and growth of these services have been more common in metropolitan areas and domiciliary settings, which suggests that reimbursement rates have not incentivized expanded delivery to lower density patient populations.[20,40]

While the IAH demonstration program through CMMI did incentivize home-based care for a subset of the FFS population, this study shows that even full-scale expansion of IAH would cast a narrow net; in the MDP, there was consensus among expert panelists to target a broader population, and analyses of the chosen HBPC algorithm revealed that IAH criteria alone would fail to capture some of the most vulnerable beneficiaries, including those that are persistently homebound.

The IAH demonstration program did help to investigate meaningful quality measures in home-based care settings, but further investment and study are needed in this arena since HBPC may vary without uniform quality measures.[13,38,41] Future studies should also examine the standardization, feasibility, and utility of documenting homebound status, transportation barriers, disability, and other indicators of vulnerability in electronic medical records, public health databases, and other nationally representative studies. Using this study's newly defined "common denominator" of HBPC target populations, it will now be possible to refine HBPC quality measures, investigate disparities in access, and quantify the associated workforce capacity needs. Lastly, the HBPC algorithm can be applied to embedded pragmatic clinical trials to prospectively evaluate the effects of HBPC on health care utilization and outcomes across multiple sites.[42] Robust analyses afforded by this algorithm will help to either quell or substantiate concerns about the costs versus benefits of the HBPC delivery model.

Limitations

Though diverse, the panel of expert professionals in this MDP were not a representative sample. While panelists were encouraged to consider a broad range of potential HBPC criteria, including ones yet to have direct

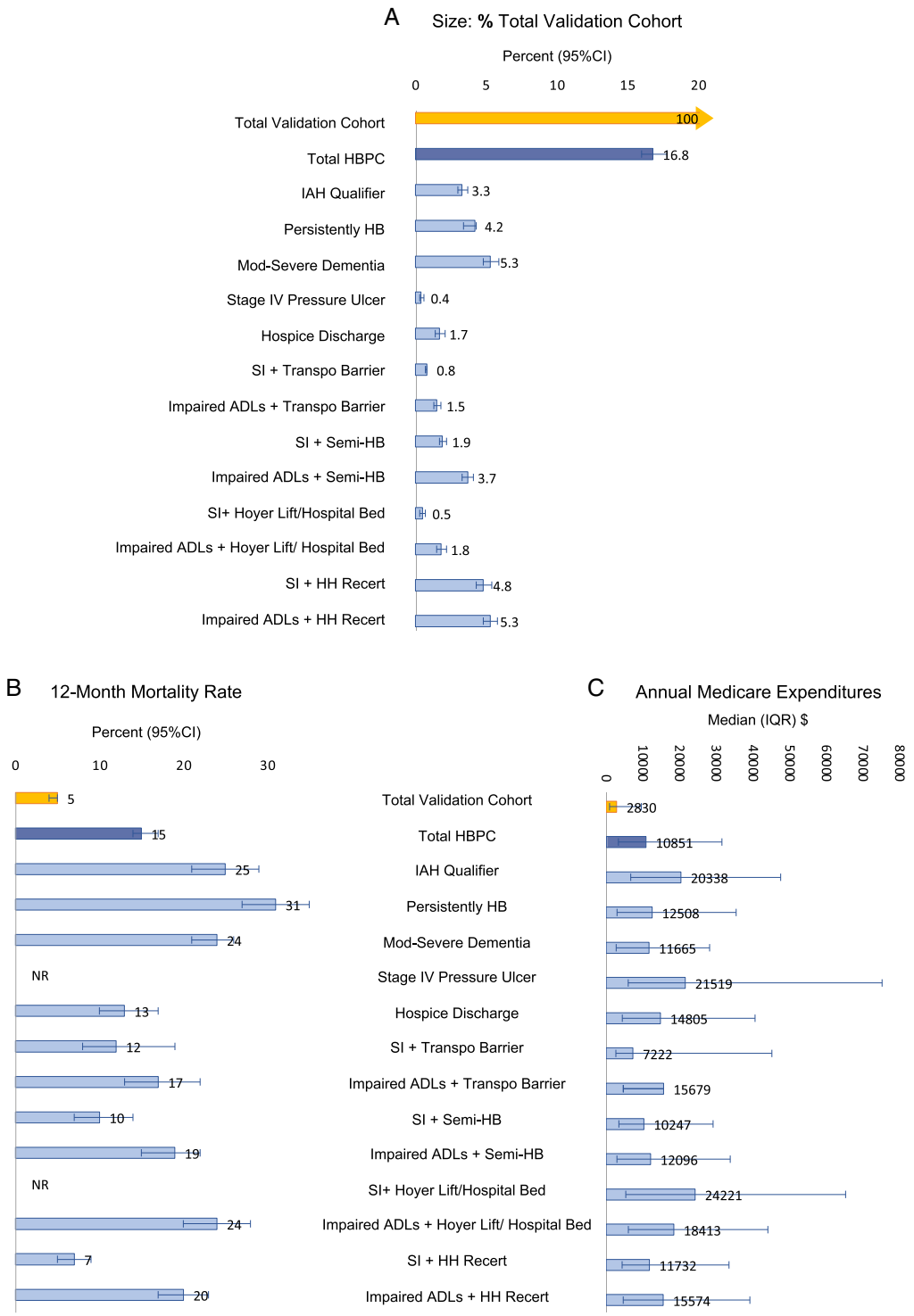

FIGURE 3. Construct validation: health care utilization and mortality among FFS Medicare beneficiaries by HBPC criteria. In a modified Delphi process, a panel of experts selected criteria for identifying HBPC target populations based on medical/social vulnerabilities (henceforth, "HBPC criteria"). Construct validation of the selected HBPC criteria was performed by linking Medicare claims with data from the 2011 to 2017 waves of the NHATS. The validation cohort was defined as community-dwelling FFS Medicare beneficiaries age $\geq$ 70 with $\geq$ 12 months of continuous enrollment. A, The proportion (95% CI) of FFS Medicare beneficiaries meeting HBPC criteria. B, The 12-month mortality rate (95% CI) among those meeting HBPC criteria as well as for the total validation cohort. C, Median (IQR) annual Medicare expenditures for those meeting HBPC criteria as well as for the total validation cohort. All estimates applied survey weights. FFS indicates fee-for-service; HBPC, home-based primary care; NHATS, National Health and Aging Trends Study.

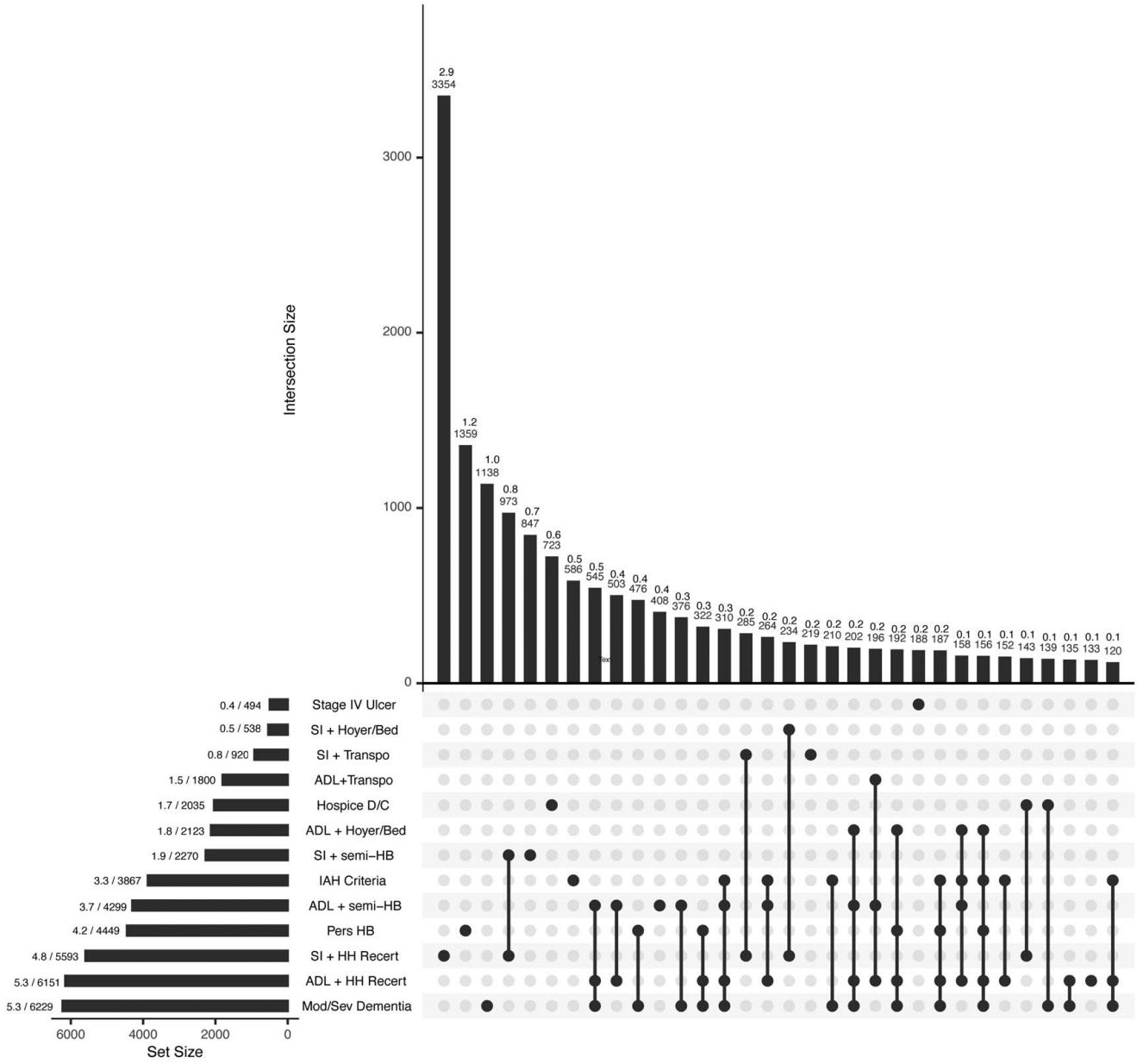

FIGURE 4. Weighted frequencies (by thousands)* at which Medicare beneficiaries met HBPC criteria, alone and/or in combination. In a modified Delphi process, a panel of experts selected criteria for identifying HBPC target populations based on medical/social vulnerabilities (henceforth, "HBPC criteria"). Construct validation of HBPC criteria was performed by linking Medicare claims with data from the NHATS. The validation cohort was defined as community-dwelling FFS Medicare beneficiaries age $\geq$70 with $\geq$12 months of continuous enrollment. Horizontal bars show the weighted number (thousands)* and weighted percent of the total validation cohort by each HBPC criterion. Vertical bars show the weighted number (thousands)* and weighted percent of the total validation cohort by unique combinations or "phenotypes" of HBPC criteria. Bars are presented from highest to lowest frequency. Due to cell size restrictions, the right-sided tail of vertical bars was unreportable and thus excluded from this figure. *The depicted weighted frequencies have been divided by 1000. HBPC indicates home-based primary care; NHATS, National Health and Aging Trends Survey.

measures in claims or health record data, the chosen HBPC algorithm was still constrained by the availability of variables in Medicare claims or NHATS, and the initial list of potential criteria was not exhaustive. Results were also affected by imperfect data capture; for instance, NHATS did not distinguish between race and ethnicity, and ICD-9 codes did not require documentation of pressure wound staging, so analyses may have vastly underestimated the number of beneficiaries meeting the stage IV pressure ulcer criterion.

CONCLUSIONS

This study defined populations who may benefit from HBPC via an expert Delphi panel. Analyses of health care utilization and outcomes supported the utility of this HBPC algorithm for health systems charged with implementing, expanding, and/or evaluating HBPC programs.

Results from this study will help to systematize and support expanded access to needed services; the HBPC algorithm can inform improvements in routine data capture (eg, homebound status) while also aiding in the prioritization of target populations that vary in size, sociodemographic makeup, vulnerability, and cost. The algorithm can thus act as a dynamic resource for payors and health systems that are implementing and scaling HBPC programs, especially when paired with policy reforms that further incentivize and regulate high-quality care in the home.

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