Validation of Secondary Commercial Data Sources for Physical Activity Facilities in Urban and Nonurban Settings

Euna Han, Lisa Powell, Sandy Slater, and Christopher Quinn

Background: Secondary data are often necessary to assess the availability of commercial physical activity (PA) facilities and examine its association with individual behaviors and outcomes, yet the validity of such sources has been explored only in a limited number of studies. **Methods:** Field data were collected on the presence and attributes of commercial PA facilities in a random sample of 30 urban, 15 suburban, and 15 rural Census tracts in the Chicago metropolitan statistical area and surrounding area. **Results:** Approximately 40% of PA establishments in the field data were listed for both urban and nonurban tracts in both lists except for nonurban tracts in D&B (35%), which was significantly improved in the combined list of D&B and InfoUSA. Approximately one-quarter of the PA facilities listed in D&B were found on the ground, whereas 40% to 50% of PA facilities listed in InfoUSA were found on the ground. PA establishments that offered instruction programs or lessons or that had a court or pool were less likely to be listed, particularly in the nonurban tracts. **Conclusions:** Secondary commercial business lists on PA facilities should be used with caution in assessing the built environment.

Keywords: validation, Dun & Bradstreet, InfoUSA, physical activity establishments

As the prevalence of obesity increased dramatically in the United States over the past few decades, researchers have explored neighborhood contextual environments as key modifiable factors to combat this epidemic.^{1,2} A number of recent studies explored the extent to which access to physical activity (PA) facilities was associated with PA-related behavior and individual body weight outcomes, particularly among youths. Previous literature reported a positive association of public and/or commercial local area PA facility availability with the level of PA.³⁻⁷ In addition, perceived availability of PA facilities was associated with higher levels of PA among middle- and high-school aged children.^{8,9} PA also was reported to have a statistically significant association with obesity prevalence among youths.^{3,10-12}

Previous studies measured variations in the built environment, particularly for commercial PA facilities, with a variety of sources including direct field observations and secondary data sources, such as telephone directories and commercial business databases. Although data on PA facilities collected in the field by trained staff can

be considered as the "gold standard," it is time intensive, costly, often focuses on a specific geographic area, and cannot be easily linked to existing national longitudinal or historical cross-sectional, individual-level data. Therefore, researchers often tend to rely on secondary data for studies examining the relationship of environmental factors for PA and individual behavioral or weight outcomes. Despite such dependence on secondary data sources, limited validation on commercial business lists of PA establishments with on the ground direct observations has been undertaken in the previous literature.

We could locate only a few previous studies that validated existing secondary data for the PA environment, 1 in Canada and 2 in the United States.¹³⁻¹⁵ These studies overall reported poor to moderate levels of validity for the secondary sources of PA facilities. Our study built on the previous studies and validated PA facility data from the 2 most widely available U.S. commercial business lists, Dun & Bradstreet (D&B) and InfoUSA, in the Chicago-Joliet-Naperville, IL-IN-WI Metropolitan Statistical Area (Chicago MSA) and surrounding nonurban areas. Our study was the first to assess the validity of PA facilities for both D&B and InfoUSA using direct field observations. We examined the level of agreement between direct field observations and information in each of the 2 secondary commercial business lists. We also used the combination of those 2 sources to assess the advantage of using combined sources. Further building on the previous literature, we collected characteristics from the interior

Han (corresponding author) is with the College of Pharmacy, Gachon University, and Gachon Institute of Pharmaceutical Sciences, Incheon, Republic of Korea. Powell, Slater, and Quinn are with the Institute for Health Research and Policy, University of Illinois at Chicago.

of each PA facility and reported whether any statistically significant differences were found in those characteristics by validation status.

Methods

Data

As part of a larger food outlet validation study,¹⁶ secondary commercial business list data on commercial PA facilities were drawn from D&B and InfoUSA and were validated with direct field observations based on a random sample of 30 urban census tracts from the Chicago MSA and a random sample of 15 suburban and 15 rural census tracts from a 50-mile buffer surrounding the Chicago MSA.

The 60 census tracts represented 1472 square miles (53 and 1419 square miles in the urban and nonurban tracts, respectively) and covered approximately 5076 total road miles (578 and 4498 miles in the urban and nonurban tracts, respectively).

Field observations were conducted from May 2009 through July 2009. Observers received 24 hours of training on the content of the data collection instruments and procedures for conducting observations including the use of maps. Observers were instructed to observe all streets within each tract as shown on the maps. Two trained field staff surveyed each census tract by walking or driving all streets contained within the tract to 1) identify any commercial PA facilities and 2) collect the presence of specific attributes inside the premises of such facilities. For each facility, data were collected on the following specific attributes: whether they charged a fee, required membership, offered instruction programs or lessons, had multiple cardiovascular and strength training equipment, had a multipurpose room, had a gymnasium, had a playing court, or had a pool. A total of 54 and 52 PA facilities were identified on the ground in the urban and nonurban tracts, respectively.

We obtained commercial data on PA facilities from D&B and InfoUSA with a reference date of May 2009. We used data on establishments with primary or secondary PA facility-related Standard Industrial Classification (SIC) codes for both D&B (8-digit) and InfoUSA (6-digit; see Table 1 for a full list of SIC codes).

All establishments in the lists were geocoded at the roof top level (the polygon centroid of a known building footprint) or street address maintained in the ArcGIS Online Geocoding Task using ArcGIS 9.1. Because our geographic sampling unit was the census tract, the remaining outlets that could only be geocoded less accurately than at the roof top or street address to the centroid of the zip code were not eligible for inclusion in our study. The geocoded locations were then matched to the census tracts using ArcGIS. We also generated a combined list of D&B and InfoUSA by manually dropping duplicated facilities by name, address, and phone number between the 2 business lists. A total of 155, 94, and 192 PA

facilities were listed in D&B, InfoUSA, and the combined list, respectively, for our sample census tracts.

Analyses

The validity of the 2 secondary commercial business lists and the combined list was assessed by 3 validity indices, including 1) Sensitivity: the proportion of establishments observed on the ground that was listed in the commercial databases; 2) Positive Predictive Value (PPV): the proportion of establishments listed in the commercial databases that was observed on the ground; and 3) Concordance: the proportion of listed PA facilities also verified on the ground among those that were either found on the ground or in the business lists. Standard errors were calculated for all indices. We used Fisher's Exact test (2-sided p) to test for significant differences in the validity indices by urbanicity and by commercial business type within each urbanicity.

For PA facilities found on the ground, we compared attributes of each facility by whether it was found in a business list. A 2-sided t test was performed to determine whether any statistically significant differences existed in the characteristics of those facilities listed in a business list versus those not listed. We also examined the distribution of primary SIC codes for PA facilities that were listed but not found on the ground and we reviewed the primary SIC codes to identify whether there were particular patterns of mismatch.

Results

Table 2 presents the validity statistics by business list and urbanicity. We found a total of 54 and 52 PA facilities on the ground in urban and nonurban tracts, respectively, whereas 77 and 78 PA facilities for D&B and 42 and 52 PA facilities for InfoUSA were listed in urban and nonurban tracts, respectively.

Sensitivity was 41% in urban tracts and 35% in nonurban tracts in D&B. Similarly in InfoUSA, sensitivity was higher in urban tracts at 39%, whereas the sensitivity in nonurban tracts was 40%. Combining the 2 commercial business lists largely improved the sensitivity across all tracts, which climbed to 52% in both the urban and nonurban tracts, respectively. The increase in the sensitivity for the urban tracts in the combined list was statistically significant compared with both D&B and InfoUSA. The differences in sensitivity between the urban and nonurban tracts were not statistically significantly different for D&B and InfoUSA, or the combined list.

Positive predictive value (PPV), the proportion of outlets listed that were observed in the field, was fair in both lists. PPV in urban compared with nonurban tracts was 29% versus 23% in D&B and 50% versus 40% in InfoUSA. PPV in the combined list in the urban tracts was 30%, whereas it was 27% in nonurban tracts. For each of the business lists and the combined list, the differences by urbanicity were not statistically significant.

Table 1 List of Standard Industrial Classification (SIC) Code for PA-Related Facilities

D&B (8-digits of Primary and Secondary SIC code)		D&B (8-digits of Primary and Secondary SIC code)	
79110000	Dance studios, schools, and halls	79970502	Racquetball club, membership
79110100	Dance hall services	79970503	Squash club, membership
79110101	Dance hall or ballroom operation	79970504	Tennis club, membership
79110102	Discotheque, except those serving alcoholic beverages	79979902	Bowling league or team
79110200	Dance instructor and school services	79979904	Country club, membership
79110201	Children's dancing school	79979906	Golf club, membership
79110202	Dance instructor	79979907	Lawn bowling club, membership
79110203	Dance studio and school	79979908	Riding club, membership
79110204	Professional dancing school	79990100	Tennis services and professionals
79330000	Bowling centers	79990101	Tennis club, nonmembership
79339900	Bowling centers, nec	79990102	Tennis courts, outdoor/indoor: nonmembership
79339901	Candle pin center	79990103	Tennis professional
79339902	Duck pin center	79990200	Golf services and professionals
79339903	Ten pin center	79990202	Golf driving range
79910000	Physical fitness facilities	79990203	Golf professionals
79910100	Physical fitness clubs with training equipment	79990204	Golf, pitch-n-putt
79910101	Athletic club and gymnasiums, membership	79990205	Miniature golf course operation
79910102	Health club	79990300	Indoor court clubs
79910103	Spas	79990301	Handball courts, nonmembership
79910200	Weight reducing clubs	79990302	Racquetball club, nonmembership
79910201	Reducing facility	79990303	Squash club, nonmembership
79910202	Slenderizing salon	79990600	Skating rink operation services
79910300	Exercise facilities	79990601	Curling rinks
79910301	Aerobic dance and exercise classes	79990602	Ice skating rink operation
79910302	Exercise salon	79990603	Roller skating rink operation
79920000	Public golf courses	79990700	Shooting facilities and archery lanes
79970000	Membership sports and recreation clubs	79990701	Archery lanes
79970100	Ice sports	79991100	Instruction schools, camps, and services
79970101	Curling club, membership	79991102	Baseball instruction school
79970102	Hockey club, except professional and semiprofessional	79991103	Basketball instruction school
79970200	Boating and swimming clubs	79991104	Bowling instruction
79970202	Boating club, membership	79991107	Diving instruction, underwater
79970203	Swimming club, membership	79991108	Games, instruction
79970400	Outdoor field clubs	79991109	Gymnastic instruction, nonmembership
79970401	Baseball club, except professional and semiprofessional	79991110	Hockey instruction school
79970402	Football club, except professional and semiprofessional	79991111	Judo instruction
79970404	Soccer club, except professional and semiprofessional	79991112	Karate instruction
79970500	Indoor/outdoor court clubs	79991113	Martial arts school, nec
79970501	Handball club, membership	79991115	Sailing instruction
		79991116	Scuba and skin diving instruction
		79991118	Skating instruction, ice or roller
		79991119	Ski instruction

(continued)

Table 1 (continued)

D&B (8-digits of Primary and Secondary SIC code)		InfoUSA (6-digit of Primary and Secondary SIC code)	
79991120	Sports instruction, schools and camps	799708	Baseball clubs
79991121	Surfing instruction	799711	Squash courts-private
79991122	Swimming instruction	799715	Country clubs
79991123	Yoga instruction	799717	Croquet clubs
79991127	Physical fitness instruction	799719	Softball clubs
79991200	Riding and rodeo services	799720	Sports clubs
79991201	Riding academy and school	799721	Volleyball clubs
79991202	Riding stable	799722	Snowmobile clubs
79991204	Rodeo operation	799723	Tee times
79991412	Swimming pool, nonmembership	799727	Rowing clubs
79991512	Waterslide operation	799728	Rugby clubs & organizations
79991513	Wave pool operation	799729	Sports recreational
79999903	Baseball batting cage	799798	Membership sports & recreation clubs
79999910	Recreation center	799901	Skating rinks
79999912	Recreation services	799902	Archery instruction
79999917	Trampoline operation	799903	Archery ranges
InfoUSA (6-digit of Primary and Secondary SIC code)		799908	Baseball batting ranges
791101	Dancing instruction	799914	Boating instruction
791104	Hula instruction	799916	Bowling instruction
793301	Bowling centers	799924	Diving instruction
794102	Soccer clubs	799929	Golf courses-miniature
794103	Basketball clubs	799931	Golf practice ranges
794105	Football clubs	799932	Golf instruction
794109	Polo clubs	799936	Gymnastic instruction
794110	Sports-indoor	799938	Handball courts
799101	Health clubs studios & gymnasiums	799944	Karate judo jiu-jitsu & kung fu instruction
799102	Gymnasiums	799945	Martial arts instruction
799103	Aerobic instruction	799949	Yoga instruction
799105	Spas (health)	799950	Water skiing instruction
799107	Pilates	799957	Riding academies
799108	Children's fitness	799958	Racquetball courts-public
799109	Senior citizen fitness	799961	Sailing instruction
799110	Medical fitness centers	799962	Skating instruction
799111	Sports & recreation facilities program	799965	Mountain climbing instruction
799201	Golf courses-public	799966	Skiing instruction
799202	Putting greens	799967	Swimming instruction
799701	Recreation centers	799968	Stables
799702	Racquetball courts-private	799969	Swimming pools-public
799703	Tennis courts-private	799970	Tennis instruction
799704	Swimming pools-private	799971	Tennis courts-public
799705	Hockey clubs	799978	Boxing instruction
799706	Golf courses-private	799994	Skateboard parks & rinks
799707	Curling clubs		

Table 2 Validation Statistics by Business List and Urbanicity

		Urban	Nonurban
D&B	Ground total	54	52
	List total	77	78
	Sensitivity	0.407 ^b	0.346
		(0.067)	(0.067)
	Positive Predictive Value	0.286 ^a	0.231 ^a
		(0.052)	(0.048)
InfoUSA	Concordance	0.202	0.161
		(0.039)	(0.035)
	Ground total	54	52
	List total	42	52
	Sensitivity	0.389 ^b	0.404
		(0.067)	(0.069)
Combined	Positive Predictive Value	0.500 ^b	0.404
		(0.078)	(0.069)
	Concordance	0.280	0.253
		(0.052)	(0.048)
	Ground total	54	52
	List total	93	99
	Sensitivity	0.519	0.519
		(0.069)	(0.070)
	Positive Predictive Value	0.301	0.273
		(0.048)	(0.045)
	Concordance	0.235	0.218
		(0.039)	(0.037)

Note. Sensitivity represents the proportion of physical activity facilities found on the ground that were listed in a business list. Positive Predictive Value is the proportion of PA facilities listed in a business list that were found on the ground survey. Concordance is the proportion of listed PA facilities also verified on the ground among those that were either found on the ground or in the business lists. Statistical significance denoted at ($P < .05$) within each characteristic as follows: ^a significant difference between D&B and InfoUSA; ^b significant difference between individual list (D&B and InfoUSA) and the combined list.

However, PPV in InfoUSA was statistically significantly higher than PPV in D&B (for both urban and nonurban tracts) and the combined list (urban tracts only; Table 2).

Finally, we calculated the proportion of listed PA facilities also verified on the ground among those that were either found on the ground or in the business lists (concordance) as a measure of the overall level of agreement. For urban tracts, InfoUSA (28%) showed higher concordance compared with D&B (20%). Overall, the agreement levels also were less than 30% in nonurban tracts in both databases (16% for D&B and 23% for InfoUSA). Combining the 2 business lists generated overall agreement levels of 24% and 22% for urban and

nonurban tracts, respectively. However, none of the differences between the urban and nonurban tracts were statistically significant nor were there any statistically significant differences in concordance, overall agreement, across list type (Table 2).

In Table 3, we show whether detailed characteristics of PA facilities on the ground were different by whether those facilities were found in the business lists. In D&B, in both urban and nonurban tracts, a higher proportion of PA facilities in the nonmatched group had a pool (28% for urban and 26% for nonurban tracts) compared with the matched group (6% for urban and 0% for nonurban tracts).

Table 3 Comparison of the Characteristics of Physical Activity Facilities Found on the Ground Survey by Listing Status

	Urban		Nonurban	
	Nonmatch	Match	Nonmatch	Match
D&B				
Charge a fee	1.000	1.000	0.962	1.000
Require membership	0.217	0.462	0.400	0.454
Offer instruction programs or lessons	0.821	0.737	0.400	0.417
Have multiple cardio & strength equipment	0.280	0.462	0.304	0.333
Have a multipurpose room	0.481	0.529	0.364	0.308
Have a gymnasium	0.111	0.059	0.000	0.000
Have a court	0.214	0.118	0.130	0.000
Have a pool	0.276	0.059*	0.261	0.000**
InfoUSA				
Charge a fee	1.000	1.000	1.000	0.929
Require membership	0.286	0.333	0.417	0.417
Offer instruction programs or lessons	0.821	0.737	0.522	0.214
Have multiple cardio & strength equipment	0.348	0.333	0.286	0.357
Have a multipurpose room	0.480	0.526	0.286	0.429
Have a gymnasium	0.148	0.000	0.000	0.000
Have a court	0.222	0.111	0.136	0.000
Have a pool	0.321	0.000**	0.273	0.000**
Combined				
Charge a fee	1.000	1.000	1.000	0.947
Require membership	0.212	0.412	0.400	0.438
Offer instruction programs or lessons	0.818	0.776	0.474	0.333
Have multiple cardio & strength equipment	0.263	0.421	0.235	0.389
Have a multipurpose room	0.429	0.565	0.250	0.421
Have a gymnasium	0.136	0.045	0.000	0.000
Have a court	0.227	0.130	0.176	0.000*
Have a pool	0.348	0.143**	0.353	0.000***

Note. Reported numbers are proportions. PA facilities found on ground that were listed in a business list were classified as "match," and the remaining PA facilities that were not listed were classified as "nonmatch." * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

In InfoUSA no statistically significant differences were found in the characteristics of PA facilities on the ground in urban tracts compared with those listed in the commercial database except for that 32% of the nonmatched PA facilities had a pool whereas none of the matched PA facilities had a pool. PA facilities in nonurban tracts that had a pool were less likely to be listed in InfoUSA: none of the listed PA establishments had a pool, whereas pools were present in 27% of the PA establishments that were on the ground but not listed in InfoUSA (Table 3).

Significant differences in the characteristics of the PA facilities between the matched and the nonmatched

groups persisted in the combined list. PA facilities in the matched group had a lower rate of having a pool (4%) compared with PA establishments in the nonmatched group (35%) in urban tracts. In addition, none of the matched PA establishments in the combined list had a court nor had a pool, whereas 18% and 35% of the nonmatched PA facilities had a court and a pool, respectively, in nonurban tracts (see Table 3).

Further, we reviewed the primary SIC codes for PA facilities that were not found on the ground but listed as such in each business list. For D&B, there were 55 and 60 such PA facilities in urban and nonurban tracts, respectively, of which the 2 most frequent types were

spas (9%) and membership sports & recreational clubs (9%) in urban tracts, and public golf courses (13%) and membership sports & recreation clubs (15%) in nonurban tracts. For InfoUSA, 21 and 31 PA facilities were not found on the ground but listed in the database in urban and nonurban tracts, respectively. The most frequent facility type listed in InfoUSA but not found on the ground in urban tracts was martial arts instruction facilities (24%) followed by stables (14%). Slightly less than one-quarter (23%) of those facilities in nonurban tracts were health club studios and gymnasiums, and 16% were public golf courses (results not shown in Tables).

We also examined the type of PA facilities that were identified on the ground but not in the list, which were 21 and 21 facilities for InfoUSA and 22 and 18 for D&B for urban and nonurban tracts, respectively. Of those, approximately 25% and 30% for nonurban and urban tracts, respectively, across the 2 business lists were local community-run recreation centers or pools, YMCAs or Jewish Community Centers (results not shown in Tables).

Discussion

We first showed that less than one-half (41% for D&B and 39% for InfoUSA) of the PA establishments found on the ground were listed for the urban tracts, and between one-third and one-half were listed in either business list for the nonurban tracts (35% for D&B and 40% for InfoUSA). Sensitivity was improved by combining the 2 business lists; the sensitivity increased to 52% for both urban and nonurban tracts in the combined list. Second, we also found that approximately only one-quarter (23% for nonurban and 29% for urban) of PA establishments listed were actually found on the ground in D&B whereas 40% (nonurban tracts) and 50% (urban tracts) of PA facilities were found on the ground in InfoUSA. Further, we found that PA establishments found on the ground that had a court or pool were less likely to be listed in either D&B or InfoUSA as well as the combined list, particularly in the nonurban tracts. The overall concordance was poor in both D&B (20% and 16% for urban and nonurban tracts) and InfoUSA (28% and 25%) and no statistically significant differences were found between the 2 lists. In sum, although InfoUSA overall showed significantly higher PPV than either D&B or the combined list, we remain cautious in suggesting which dataset is more useful given that the differences of sensitivity and concordance between D&B and InfoUSA were not statistically significant, and the sensitivity improved in the combined list.

The validation statistics from our results were comparable to the previous literature, although we could locate only 3 studies that validated secondary data sources for the PA environment.¹¹⁻¹³ Paquet and colleagues validated 1 commercial database and a business list based on internet searches in 2005 for food stores and PA facilities for 12 census tract boundaries in Montreal, Canada.

They reported 56% for sensitivity, 63% for PPV, and concordance of 25%.¹¹ Boone and colleagues assessed 1 commercial database with commercial PA facilities in 80 census block groups in 1 urban and 1 nonurban community in the United States in 2005. They reported concordance of 39% and 46% for urban and nonurban communities, respectively, for all PA facility types combined.¹² Lastly, Hoehner and Schootman¹⁵ compared D&B and InfoUSA to examine agreement between the 2 sources in terms of the presence, locations, and characteristics of businesses for PA facilities as well as food stores and restaurants. Based on 4-digit SIC codes provided in each list, they matched businesses in each list in the St. Louis, Missouri area in 2007 by business name within specified distances. They reported that the level of agreement between the 2 secondary sources on commercial PA establishments was 63% and varied by population density in a given census-tract. However, this latter study did not validate each list based on actual field survey data.¹³

The quality of secondary data sources in evaluating PA environments is important to reach credible conclusions when using such databases. Accurately identifying PA facilities in a neighborhood using business lists may require more efforts compared with food stores and restaurants given the large variety of PA facility types with both public and private sources.¹¹ A previous study that reported agreement between D&B and InfoUSA of 63% for PA facilities, reported a higher level of agreement (75% to 92%) for food stores and restaurants.¹⁵ Similarly, an international study also reported that all validation statistics including the percentage agreement, sensitivity, and PPV were all superior for food stores compared with PA-related businesses (65% to 77% for food stores versus 25% to 42% for PA facilities for the percentage agreement; 66% to 84% for food stores and 33% to 56% for PA facilities for sensitivity; and, 58% to 98% for food stores and 50% to 63% for PA facilities for PPV).¹³

The results of this study are subject to a few limitations. First, our ground-truth survey data are based on 1 metropolitan urban area and surrounding nonurban area in the United States at a single point in time, and thus, whether the results of this study can be generalized across the United States is not known. Second, our field staff could only identify stand-alone facilities with clear PA indications although we performed a census for the sampled census tracts to identify PA facilities and collected their attributes inside each establishment. Therefore, if there were any individuals who were offering PA instruction in their home, for example, and listed themselves as a PA related business (not as an individual trainer) in a business list, such places were not included in our ground survey. Third, for this study we purchased the commercial business lists by SIC codes and did not provide any text strings to further obtain the list of PA facilities in those lists. Our findings indicated that governmental and nonprofit PA facilities that were found on

the ground, particularly in nonurban tracts, were unlikely to be present in the business lists. This suggests that the business lists are less accurate at capturing information on governmental and nonprofit PA facilities in nonurban areas, or that these outlets are not recorded with PA-related SIC codes. Given that the prevalence of obesity is found to be significantly higher¹⁷⁻¹⁹ and PA is found to be significantly lower^{17,19,20} in nonurban populations, it is particularly important to accurately identify whether area-level disparities exist in PA resources including specific sports or activity features. However, we acknowledge that using text strings in addition to SIC codes could improve sensitivity. In addition, relying SIC codes in the commercial business lists to identify PA facilities restricted our understanding of the characteristics of listed facilities that were not discovered on the ground which may include closed businesses, misclassified listings, and corporate offices. Finally, our sample size is small; however, similar studies also had small sample sizes and our findings are similar to those found in another study in the United States.¹² Despite these limitations, the current study built on the previous literature by validating the spatial patterning of PA establishments in 2 commercial secondary data sources in both urban and nonurban areas including information of the characteristics of the PA facilities surveyed on the ground.

Conclusions

Our study results indicate that the 2 secondary commercial business lists should be used with caution in assessing the built environment regarding PA facility availability. Combining the 2 business lists has an advantage in that researchers more accurately include what is actually on the ground when they use such lists to measure the PA environment. However, such improvement in the sensitivity is obtained at the expense of the deterioration of PPV and concordance. Therefore, the improved sensitivity in the combined lists is only useful when researchers can perform initial screening via phone to eliminate any closed PA facilities that remain in those lists. Such initial screening via phone would be a good alternative to the expense of ground truthing in a medium size study; but this may not be feasible for a large study.

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