# Assessment of Quality Assurance Failure Rates for Commonly Used Diagnostic Media: Results of a College of American Pathologist Questionnaire in 2001

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### AMENDED ABSTRACT

**Background:** Beginning in 1985, state-of-the-art surveys by the College of American Pathologists (CAP) led to NCCLS M22-A guidelines for quality assurance (QA) of various isolation and diagnostic microbiology media. Some medium types were declared exempt from routine QA testing by each laboratory user, but manufacturer QA was maintained and specified in great detail. No update has occurred in over 15 years as more complex mediums were introduced in to clinical microbiology practice.

Methods: A questionnaire was designed conforming to that used by the CAP in 1985 and 1988, and updated by lists of 52 recently introduced diagnostic medias. Queries included details of laboratory QA in the last 12 months: no. of lots tested, no. of items in lots, no. of items in QC sample, no. of lots failed and reasons for failure (5 total, 2 QC strains-based). All CAP Microbiology Surveys participants received the document in late 2001.

Results: Data from over 300,000 media lots representing 32.7 million medium items were received from over 3,000 CAP Surveys subscribers. Lot failure rates ranged from 0.10 to 9.87% (ave. 1.01%). Failures adjusted for QC strain-based failures (so-called "extrapolated failure rate") ranged from 0.04 - 1.34 (ave. 0.40%). Threshold rate for QA exemption from 1985 analyses was 0.30% now allowing exemption of 18 newer different media, but local laboratory QA must remain in force (M22-A2) for other products including mycobacterial Septicheck, several mycology media (BIGGY agar highest at 9.87%), 2 B. pertussis, 2 B. cepacia agars and 3 broth media (Todd-Hewett, Trans-Vag, Nutrient). The complete list of exempt media will be presented, now including several STD and anaerobic mediums.

Conclusions: Generated QA failure results from the CAP Surveys, supplement recent results of the NCCLS M22 subcommittee that will lead to more practical media QA guidelines, and could dramatically decrease costs for clinical microbiology laboratories through focusing QA on the most at-risk diagnostic products.

# INTRODUCTION

The National Committee for Clinical Laboratory Standards (NCCLS) developed a standard entitled "Quality Assurance for Commercially Prepared Microbiological Culture Media" beginning in 1984. This resulted in progressive proposed, tentative and finally approved documents (M22-P, M22-T, M22-A, and M22-A2) being published in 1985 - 1996. The basic premise of the standards has been that "retesting of commercially prepared microbiological culture media imposes a substantial financial burden on the clinical microbiology laboratory and might not be necessary for these media that are of proven reliability". The proof of reliability was initially obtained from questionnaires circulated by the College of American Pathologists (CAP) Microbiology Resource Committee (MRC) dating from Survey samples B-A and D-A in 1984. MacLowry et al. described the results of respondents from 1,164 laboratories that collectively contributed quality control (QC) data from more than 350,000 lots of 35 different types of prepared media. Analysis of these data suggested that media QC failure rates were rare (approximately 0.5%) and a table of QC exempt media was placed in the drafts of the NCCLS M22 document generally indicating "extrapolated failure rates of  $\leq 0.3\%$ ".

The NCCLS M2-A2 has not been revised since 1996 and a survey of contemporary QC medium results has not been forthcoming. Only 27 of 35 media tabulated in 1985 were tested in sufficient numbers to be listed in the M22 document and numerous new diagnostic media have been introduced into routine clinical microbiology use in the last 15 years. Therefore, the CAP-MRC developed and circulated a guestionnaire in collaboration with the NCCLS Subcommittee on Culture Media. This survey solicited QC information for 52 different media, only four in common with the previously published survey. We report the results of that questionnaire, hopefully leading to contemporary changes in the list of QC-exempt culture media with the analyses conforming to those precedents described in the earlier CAP publication.

# MATERIALS AND METHODS

Survey questionnaire. The media QC questionnaire was developed with the input from the NCCLS subcommittee to list 52 contemporary media, four in common with the previous survey (chocolate agar, Thayer Martin agar, Mitchinson's 7H11, and inhibitor mould agar). Specific questions were asked regarding the QC results for the preceding 12-month period as follows: total number of lots tested, total media items for the 12-month period, total number of media used for QC, total number of lots failing QC, and the reason for the lot failure. The latter question could have multiple responses and the possible answers were: no growth, no inhibition, non-sterile, haemolysis and surface defects. This questionnaire was circulated with CAP Surveys specimens D-C (2001) and tabulated in early 2002.

Analysis of results. QC results from more than 3,000 CAP Microbiology Surveys participants were received. These data covered the testing of over 300,000 medium lots for 32.7 million items of media. The volume of QC experience compared favorably to that reported in 1985, where 351,340 lots were recorded covering 67.6 million media items. The greater numbers (lots and items) in the prior survey indicates the greater emphasis on the most commonly used medium types (primary isolation media; example, 24 million items for blood agar alone). This Survey's questionnaire listed 52 more specialized media, many developed in the last 15 years. The returned questionnaires from participant laboratories reflected the demographic profile of all CAP Microbiology Surveys subscribers as to geographic distribution, bed capacity of hospitals served and other monitored parameters.

Failure rates (%) were calculated as a raw score of "total number of lots failing QC/total number of lots tested". An extrapolated rate was then established by determining what proportion of the raw rate that was attributed to some type by testing failure of a QC organisms. As an example, the raw failure rate for chocolate agar was 0.36%, but only 64 of 137 failures with a defined reason were attributed to QC organism results or 46.7%. The extrapolated rate for this medium would be 0.36% x 0.467 = 0.17% (see Table 3). Furthermore, only those media with significant sample size or QC experience were tabulated. Only media with > 1,000 lots and/or > 100,000 items of production experience had the extrapolated rate determined. These analysis criteria were consistent with those utilized by the CAP in 1985.

- The number of lots evaluated by QC among CAP Surveys participants varied from 62,119 (chocolate agar) to only 88 (Trans-Vag broth). Overall, items of media by type ranged from 15.7 million (chocolate agar) to 2,729 (BIGGY agar).

- Table 2.
   Reasons listed for C
   screened Medium Chocolate Thayer-Martin BACTEC bottle LIM Broth (TH w/CNA) MacConkey w/Sorbitol Campy blood (Blaser) Selective strept agar Martin-Lewis BacT/Alert bottle CDC laked blood w/KV GCII (CA/IsoVitaleX) CDC sheep blood w/KV Bacteroides bile esculin Brucella w/Hemin/Vita. K CDC sheep blood w/PEA Inhibitory mould agar Kanamycin laked blood Brucella agar Todd-Hewitt (TH) GC-Lect agar SXT agar BHI with sheep blood w/CG TSA with sheep blood w/Amp TCBS (V. cholerae) SAB w/CG Brucella laked blood w/KV Charcoal selective Nutrient broth Reagan-Lowe agar Legionella selective Potato dextrose agar PC (Burkholderia) Cornmeal w/tween Cornmeal Egg yolk (modified) Inhibitory mould agar w/G BHI with sheep blood w/C

- Raw failure rates ranged from 0.10 to 9.87% (Table 1).
- Thirty-eight (73%) of the 52 monitored media met the inclusion criteria for exemption analysis of "extrapolated failure rates". Failure rates for these media when corrected for QC organism-based failures ranged from only 0.04 to 1.34% (Tables 2 and 3). In 1985, 77% of media (27 of 35) met the analysis criteria.

 Table 1.
 Results from the CAP Surveys questionnaire (D-C, 2001) on quality control testing of 52 types of commercial media.

Media types/medium	Total no. lots tested	Total no. items in study	Total no. lots failing QC	Total no. media used for QC	% of lots failed	No. of users	Mean no. lots tested	Mean no. items/lots	Mean no. of items
General media Chocolate	62,119	15,710,003	233	161,585	0.36%	2,145	29.0	7,727	76
Brucella agar	2,760	352,424	7	4,788	0.30%	2,145 522	5.3	1,249	20
Campylobacter media									
CVA	18,002	1,243,779	131	37,303	0.73%	1,029	17.5	1,496	44
Campy blood (blaser)	20,406	1,028,332	146	44,101	0.72%	1,235	16.5	977	41
Charcoal selective	2,372	133,839	16	4,186	0.67%	453	5.2	616	22
GC media	00 704	4 77 4 000	470		0.040/		10.0		
Thayer-Martin Martin-Lewis	26,761 8,053	1,771,833 851,763	170 42	63,030 19,824	0.64% 0.52%	1,641 719	16.3 11.2	1,181 1,680	41 40
GC-Lect agar	2,815	281,869	13	7,647	0.46%	515	5.5	1,036	30
GC-II (CA w/IsoVitaleX)	1,679	439,831	23	4,948	1.37%	438	3.8	2,210	30
Anaerobic media									
Bacteroides bile esculin	7,472	419,733	29	12,775	0.39%	730	10.2	829	26
Kanamycin laked blood Brucella laked blood w/KV	3,110 2,444	365,545 163,797	12 21	4,261 3,928	0.39% 0.86%	491 528	6.3 4.6	1,479 566	19 15
Brucella w/Hemin/Vita K	2,444 3,639	399,979	15	7,394	0.80%	528 554	4.0 6.6	1,246	26
CDC sheep blood w/KV	7,132	436,336	30	13,522	0.42%	661	10.8	547	16
CDC laked blood w/KV	7,145	453,158 383 557	26 132	11,143 10 778	0.36%	600 608	11.9 10.7	1,132	31 28
CDC sheep blood w/PEA Egg yolk (modified)	6,504 1,346	383,557 50,580	132 8	10,778 2,909	2.03% 0.59%	608 469	2.9	917 210	28 14
	•								
Mycobacteria media 7H9 broth	836	69,542	1	2,726	0.12%	462	1.8	295	13
BacT/Alert bottle	995	742,626	1	1,636	0.10%	455	2.2	3,200	8
BACTEC bottle	4,658	1,458,169	37	10,529	0.79%	617	7.6	3,645	28
Septicheck Mitchison's 7H11	959 795	68,420 77,482	32 4	1,811 1,258	3.34% 0.50%	649 432	1.5 1.8	58 391	1 8
		,		.,	0.0070				
Fungal media BHI w/sheep blood w/CG	3,494	258,575	12	5,848	0.34%	538	6.5	805	20
BHI w/sheep blood w/CG	3,494 287	23,091	12	5,646	0.34 <i>%</i> 4.18%	387	0.5	160	20 5
BHI w/sheep blood w/CC	1,087	82,059	16	1,801	1.47%	514	2.1	412	11
BIGGY agar	152	2,729	15	151	9.87%	524	0.3	9	<1
Birdseed agar	363	5,808	5	564	1.38%	612	0.6	15	2
Cornmeal agar Cornmeal agar w/Tween	1,722 1,737	34,842 57,659	20 42	3,094 3,670	1.16% 2.42%	754 566	2.3 3.1	35 167	3 11
Dermatophyte test medium		32,359	9	2,221	1.08%	505	1.7	114	9
Inhibitory mould agar	3,934	381,494	25	8,093	0.64%	576	6.8	1,068	25
Inhibitory mould agar w/G	1,232	95,156	3	2,313	0.24%	461	2.7	485	14
Potato dextrose agar Potato flakes agar w/woCC	1,877 805	92,335 62,917	28 9	3,467 1,845	1.49% 1.12%	597 571	3.1 1.4	237 185	10 6
SAB w/CG	2,018	166,592	5	3,612	0.25%	641	3.2	155	3
Specialty media Legionella selective	2,371	76,485	13	4,151	0.55%	521	4.6	268	17
Legionella selective w/DGV	'P 484	17,219	2	1,610	0.41%	409	1.2	103	12
Selective strep agar	6,781	878,304	7	14,493	0.10%	609	11.1	2,234	40
SXT agar MacConkey w/Sorbitol	2,551	279,062	8 202	4,562	0.31%	481	5.3 14.8	1,107 881	21 29
Bordet gengou blood agar	19,346 684	1,038,153 10,860	202	33,498 992	1.04% 0.88%	1,306 521	14.8	37	29 4
Reagan-Lowe agar	3,853	52,044	81	4,261	2.10%	636	6.1	52	4
OFPBL (B. cepacia)	781	22,128	12	1,487	1.54%	417	1.9	129	10
PC (B. cepacia)	1,867	44,245	9 4	2,679	0.48%	450	4.2	202	14 7
CA agar w/Bacitracin CA agar w/Pyridoxal	405 128	65,720 50,806	4 3	864 326	0.99% 2.34%	394 395	1.0 0.3	435 379	3
TCBS (V. cholerae)	3,073	205,251	20	6,068	0.65%	690	4.5	424	13
TSA w/sheep blood/Amp	1,102	247,849	22	3,360	2.00%	515	2.1	888	14
Broth media									
Todd-Hewitt (TH)	2,130	300,131	20	3,237	0.94%	640	3.3	325	3
LIM Broth (TH w/CNA)	4,793	1,083,196	15	11,958	0.31%	870	5.5	1,536	18
Trease Manufacture (1)	00	7 700	<u>^</u>	040	0 4404	004	~ ~		<u> </u>
Trans-Vag broth Nutrient broth	88 985	7,769 125,398	3 13	213 3,547	3.41% 1.32%	384 454	0.2 2.2	52 542	2 18

### RESULTS

Among media common to both 1985 and 2002 databases, the extrapolated failure rates were similar (examples: chocolate agar 0.18% [1985] and 0.17% [2002]; Thayer-Martin agar 0.31% [1985] and 0.49% [2002]).

• In contast to 1985 results, fewer media met exemption criteria of  $\leq 0.30\%$  failure rate, only 18 of 38 analyzed media. In 1985, 25 of 27 media had extrapolated failure rates of  $\leq 0.18\%$  with only Campylobacter agar (0.39%) and Thayer-Martin agar (0.31%) requiring continued user QC.

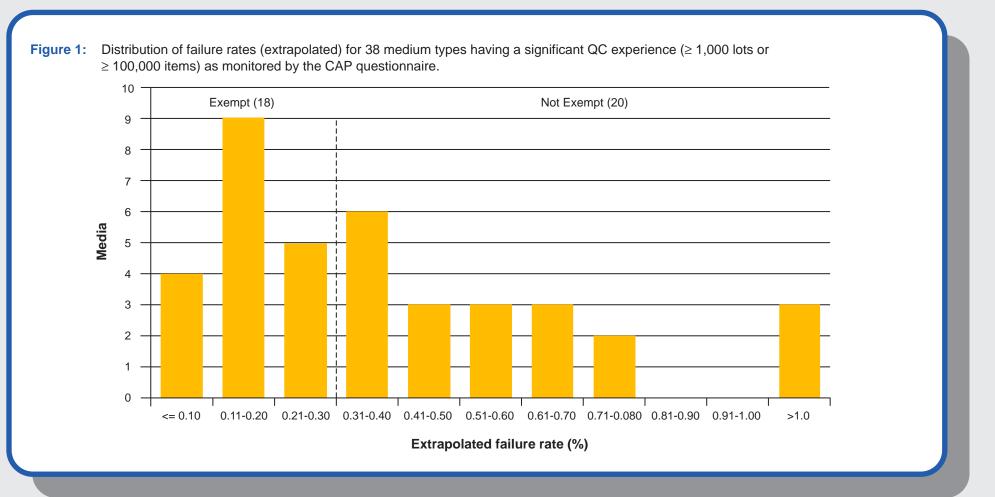
QC failures of monitored media (n=832).	
Reason	No. response
No growth	332
No inhibition	155
Non-sterile	149
Haemolysis	60
Defect, surface or other	136

**Table 3.** Raw and extrapolated lot failure rates for 38 media having significant QC experience data as defined by  $\geq$  1,000 lots or  $\geq$  100,000 items

		No. of lots failed with reason		Failure rates (%)		
No. of items	No. of lots	Total	QC strains	Raw	Extrapolated <sup>a</sup>	
15,710,003	62,119	137	64	0.36	0.17 <sup>b</sup>	
1,771,833	26,761	98	76	0.64	0.49	
1,458,169	4,658	6	2	0.79	0.26 <sup>b</sup>	
1,243,778	18,002	57	47	0.73	0.60	
1,083,196	4,793	18	14	0.31	0.24 <sup>b</sup>	
1,038,153	19,346	34	20	1.04	0.61	
1,028,332	20,406	76	57	0.72	0.54	
878,304	6,781	13	5	0.10	0.04 <sup>b</sup>	
851,763	8,053	15	15	0.52	0.52	
742,626	995	6	3	0.10	0.05 <sup>b</sup>	
453,158	7,145	16	9	0.36	0.20 <sup>b</sup>	
439,831	1,679	14	7	1.37	0.68	
436,336	7,132	26	11	0.42	0.18 <sup>b</sup>	
419,733	7,472	18	8	0.39	0.14 <sup>b</sup>	
399,979	3,639	11	3	0.41	0.11 <sup>b</sup>	
383,557	6,504	13	5	2.03	0.78	
381,494	3,934	8	5	0.64	0.40	
365,545	3,110	10	4	0.39	0.15 <sup>b</sup>	
352,424	2,760	8	4	0.25	0.13 <sup>b</sup>	
300,131	2,130	6	4	0.94	0.63	
281,869	2,815	17	11	0.46	0.30 <sup>b</sup>	
279,062	2,551	15	5	0.31	0.10 <sup>b</sup>	
258,575	3,494	19	6	0.34	0.17 <sup>b</sup>	
247,849	1,102	13	2	2.00	0.31	
205,251	3,073	19	9	0.65	0.27 <sup>b</sup>	
166,592	2,018	6	2	0.25	0.08 <sup>b</sup>	
163,797	2,444	18	7	0.83	0.33	
133,839	2,372	12	7	0.67	0.39	
125,398	985	2	2	1.32	1.32	
52,044	3,853	13	8	2.10	1.29	
76,485	2,371	13	9	0.55	0.38	
92,335	1,877	6	2	1.49	0.50	
44,245	1,867	4	4	0.48	0.48	
57,659	1,737	9	5	2.42	1.34	
34,842	1,722	7	2	1.16	0.33	
50,580	1,346	7	3	0.59	0.25 <sup>b</sup>	
95,156	1,232	2	1	0.24	0.12 <sup>b</sup>	
82,059	1,087	8	4	1.47	0.74	

a. Extrapolated failure rate represents that rate resulting from QC organism testing and excludes other reasons such as sterility, haemolysis, surface defects, etc. . Failure rates meeting the criteria for exemption as published previously by the NCCLS M22-A.

- Chocolate agar BACTEC bottles LIM broth Selective strept agar BacT/Alert bottles Brucella agar CDC laked blood w/KV GC-Lect agar
- NCCLS exemption list (Figure 1).



- from user QC.

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The following media should be listed on the NCCLS QC exemption list ( $\leq 0.30\%$  failure; see Table 3): CDC sheep blood w/KV SXT agar Bacteroides bile esculin BHI w/sheep blood or CG Brucella w/hemin/vit. K TCBS SAB w/CG Kanamyin laked blood Egg yolk (modified) Inhibitory mould agar w/G

Application of a less strict qualifying failure rate (example,  $\leq 0.50\%$ ) would only add nine more media to the

# CONCLUSIONS

• The collaboration of the CAP and NCCLS subcommittees has again clarified the media with proven reliability via a CAP Microbiology Survey's questionnaire.

A total of 18 media (17 new additions) should be considered for the list to be exempt

These findings should reduce the need for routine QC in clinical microbiology laboratories and further minimize the cost of local quality assurance of commercially-prepared medias.

### REFERENCES