Knowledge, Attitudes and Practices Regarding Antibiotic Use and Resistance among Veterinary Students in Bangladesh

Lorraine Chapot 1,†, Md Samun Sarker 2,†, Ruhena Begum 2,†, Delower Hossain 3,†, Rahima Akter 4,†, Md Mehedi Hasan 5,†, Zamila Bueaza Bupasha 6,†, Md Bayzid 7,†, Md Salauddin 8,†, Md Shafullah Parvej 9,†, AHM Musleuh Uddin 10, Fazlul Hoque 11, Joya Chowdhury 9, Md Niymat Ullah 12, Md Kaisar Rahman 13,†, Nure Alam Siddiky 2,†, Guillaume Fournié 1 and Mohammed A. Samad 2,∗

Pathobiology and Population Sciences, Royal Veterinary College, London NW1 0TU, UK; lchapot18@rvc.ac.uk (L.C.); gfournie@rvc.ac.uk (G.F.)
Antimicrobial Resistance Action Center (ARAC), Bangladesh Livestock Research Institute (BLRI), Doha 1341, Bangladesh; samuncvasu@gmail.com (M.S.S.); dr.ruhenabegum@gmail.com (R.B.);
nasiddiky.saar@gmail.com (N.A.S.)
Department of Medicine and Public Health, Sher-e-Bangla Agricultural University, Doha 1207, Bangladesh; delowervet@sau.edu.bd
Department of Pharmacy, World University of Bangladesh, Doha 1205, Bangladesh; shipa.ju93@gmail.com
Department of Medicine, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh; hasan.vet39856@bau.edu.bd
Department of Microbiology and Veterinary Public Health, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; bupasha1494@gmail.com
Department of Pathology and Parasitology, Chattogram Veterinary and Animal Sciences University, Chattogram 4225, Bangladesh; md.bayzid18fv@gmail.com
Department of Microbiology, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh; salauddin.dvm@gmail.com
Gono Bishawabidyalay, Doha 1344, Bangladesh; drparvejbd@gmail.com (M.S.P.);
joyachowdhury.cvasu@gmail.com (J.C.)
Department of Surgery and Theriogenology, Sylhet Agricultural University, Sylhet 3100, Bangladesh; musleuh.dsv@bau.ac.bd
Veterinary Medicine, Bangandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh; bsraufaazul@gmail.com
Department of Veterinary and Animal Sciences, University of Rajshahi, Rajshahi 6205, Bangladesh; nijam18340@gmail.com
EcoHealth Alliance, New York, NY 10001-2320, USA; kaisarrahman@ecohealthalliance.org
* Correspondence: msamad@blri.gov.bd; Tel.: +880-1717047877
† The authors have equal contribution.

Abstract: The use of antibiotics in animals for both therapeutic and non-therapeutic purposes is a major driver of the emergence and spread of antimicrobial resistance (AMR). While several studies have investigated prescription and consumption patterns in humans, little attention has been paid to the veterinary sector. A cross-sectional study was conducted in 3002 veterinary students (VS) and non-medical students (NMS) from 12 universities in Bangladesh to explore their knowledge, attitudes and practices (KAP) about antibiotics and AMR using a self-administered questionnaire, and assess the influence of the veterinary curriculum. KAP regarding antibiotic use and AMR was significantly higher in veterinary than non-medical students, and in first-year than final-year students. However, gaps in knowledge and practices were highlighted, suggesting deficiencies in training. Moreover, final-year veterinary students were found to be more likely than first-year students to use antibiotics without instructions, which could indicate deficiencies in their curriculum. Although the study suggested a positive impact of the veterinary curriculum on KAP about antibiotics and AMR in Bangladesh, critical gaps remain that are likely to contribute to inadequate use in their future practice. Therefore, there is scope for improving educational programs on AMR in professional curricula.

Keywords: antimicrobial resistance; knowledge; attitudes and practices (KAP); Bangladesh; veterinary medicine
1. Introduction

Over the past decades, antimicrobial resistance (AMR) has emerged as one of the greatest global public health threats, compromising our ability to control infectious diseases and undermining essential medical advances [1,2]. Currently, it is estimated that AMR is responsible every year for at least 700,000 deaths worldwide. If no further actions are taken to address this threat, the number of annual deaths is projected to reach 10 million in 2050, with nearly half of these occurring in Asia [3]. Its consequences remain largely underestimated in low- and middle-income countries (LMIC) where antibiotics are extensively used to compensate for poor sanitary conditions, lack of diagnostic tools and limited access to alternative treatments [1,4–6].

While any use of antimicrobials can contribute to AMR emergence, it is now widely acknowledged that excessive usage and sub-therapeutic dosage are the main drivers of resistance [1,7–9]. As the development of novel replacement drugs is by far outpaced by the speed of AMR emergence and spread [1–3], greater emphasis should be placed on promoting appropriate use of antimicrobials. Several studies have demonstrated that mis-usage was mostly attributable to a lack of awareness among practitioners and poor adherence of users to prescription guidelines [4,10–13]. Furthermore, self-medication remains a widespread practice in many developing countries. This is facilitated by the availability of drugs over-the-counter despite increasing efforts to legislate [4,11,14–17]. Health professionals can play an essential role in AMR risk mitigation by raising patients’ awareness about the consequences of improper use and non-adherence to dosage regimens. It is therefore crucial to ensure they have adequate knowledge to adopt rational prescribing practices [9–11,18,19]. Indeed, WHO’s 2015 Global Action Plan (GAP) emphasized the urgent necessity to make AMR a core component of health education [20].

In line with this objective, recent studies have targeted medical students to better understand the factors influencing antimicrobial use by future prescribers [12,19,21–25], but few have conducted similar investigations in veterinary students [6,13,26]. Their role in the implementation of preventive measures is, however, of great importance: it has been estimated that more than half of the total amount of antimicrobials used worldwide are consumed by food-producing animals [5,8,9,27]. With a growing body of evidence highlighting their role as potential reservoirs of zoonotic resistant pathogens, antimicrobial use in animal production is a major concern [2,5,6,8,27]. In particular, the extensive use of antimicrobials for non-therapeutic purposes, including metaphylaxis and growth promotion, has been identified as a strong determinant of the emergence and spread of AMR [8,9,11,28,29]. Despite an increasing number of countries introducing regulation, enforcement is often limited by a lack of commitment from stakeholders and insufficient monitoring of AMR prevalence and antimicrobial use in animals [2,8,9,30].

In Bangladesh, the government established a National Action Plan (BNAP) in May 2017 to address the issue of AMR in line with the WHO GAP objectives [20,31,32]. However, the lack of surveillance frameworks, limited resources and poor awareness among professionals and policy makers are still hindering its effective implementation [14]. Unlicensed drug shops continue to provide easy access to antibiotics without prescription for both humans and animals, while unregulated drug promotion by pharmaceutical companies exacerbates indiscriminate consumption [29,33,34]. Furthermore, important policy gaps remain regarding antimicrobial stewardship and monitoring of use in the veterinary sector [32,35]. Unlike other countries such as Thailand, the BNAP does not set clear objectives for reducing non-therapeutic use in animals. Although it mentions the inclusion of AMR and rational antimicrobial administration practices in all health curricula, there is little evidence of its implementation in veterinary schools [32]. Studies investigating knowledge, attitudes and practices (KAP) among health professionals and students in Bangladesh are scarce and have focused mostly on human health professionals [18]. In this study, we aim to assess KAP associated with antibiotic use and AMR among veterinary students (VS), and compare it with KAP among non-medical students (NMS) to assess the influence of their curriculum.
2. Results

We conducted a cross-sectional study from November 2019 to March 2020 to investigate KAP regarding antibiotic use and AMR among 3002 veterinary and non-veterinary students from 12 public universities in Bangladesh using a self-administered paper-based questionnaire. Participants were recruited in various faculties through opportunistic sampling. The survey questionnaire was designed with the following objectives: (1) to describe students’ KAP regarding the use of antibiotics in VS and NMS; and (2) to compare KAP between first and final year VS to assess the impact of their curriculum.

2.1. Demographics

Out of the 3002 returned questionnaires, 173 were rejected because they were incomplete ($n = 149$) and/or filled by non-veterinary, but medical students ($n = 24$), leaving 2829 for analysis. Table 1 summarizes the participants’ demographic characteristics. The age of participants ranged from 17 to 29 years-old, with a mean of 21.57. Most participants were male (57.69%). There was a significantly higher proportion of males and lower proportions of last year and master’s students in VS compared to NMS. Most NMS were enrolled in studies related to agriculture (32.97%) and fisheries (17.56%).

Table 1. Characteristics of participants.

| Characteristic         | % (n) Total (N = 2829) | % (n) VS (N = 1428) | % (n) NMS (N = 1401) | p (Fisher’s Test) |
|------------------------|------------------------|---------------------|----------------------|-------------------|
| Gender                 |                        |                     |                      |                   |
| Female                 | 42.31 (1197)           | 28.99 (414)         | 55.89 (783)          | <0.001            |
| Male                   | 57.69 (1632)           | 71.01 (1014)        | 44.11 (618)          |                   |
| Age (mean ± SD)        |                        |                     |                      |                   |
| 17–20                  | 21.58 ± 1.71           | 21.52 ± 1.69        | 21.64 ± 1.73         | 0.079             |
| 21–24                  | 28.35 (802)            | 28.78 (411)         | 27.91 (391)          |                   |
| 25+                    | 66.35 (1877)           | 66.87 (955)         | 65.81 (922)          |                   |
| Year of study          |                        |                     |                      |                   |
| First (undergraduate)  | 18.35 (519)            | 18.98 (271)         | 17.70 (248)          | <0.001            |
| Intermediate years     | 65.68 (1858)           | 72.20 (1037)        | 58.60 (821)          |                   |
| Last (undergraduate)   | 11.59 (328)            | 6.72 (96)           | 16.56 (232)          |                   |
| Master’s               | 4.38 (124)             | 1.68 (24)           | 7.14 (100)           |                   |
| Faculty                |                        |                     |                      |                   |
| Agribusiness & Marketing | 3.39 (96)              | -                   | 6.85 (96)            |                   |
| Agricultural engineering & Technology | 1.34 (38) | - | 2.71 (38) |
| Agriculture            | 11.59 (328)            | -                   | 23.41 (328)          |                   |
| Fisheries              | 8.69 (246)             | -                   | 17.56 (246)          |                   |
| Food Sciences          | 0.67 (19)              | -                   | 1.34 (19)            |                   |
| Animal Husbandry       | 2.76 (78)              | -                   | 5.58 (78)            |                   |
| Veterinary Medicine    | 50.48 (1428)           | 100 (1428)          | -                    |                   |
| Biological Sciences    | 4.70 (133)             | -                   | 9.49 (133)           |                   |
| Business Studies       | 1.70 (48)              | -                   | 3.43 (48)            |                   |
| Engineering            | 2.33 (66)              | -                   | 4.71 (66)            |                   |
| Mathematical and Physical Sciences | 1.91 (54) | - | 3.85 (54) |
| Computer Science & Engineering | 2.58 (73) | - | 5.21 (73) |
| Social Sciences        | 6.82 (193)             | -                   | 13.78 (193)          |                   |
| Arts                   | 1.03 (29)              | -                   | 2.07 (29)            |                   |

VS = Veterinary Students; NMS = Non-Medical Students; SD: standard deviation.
2.2. Knowledge about Antibiotics and AMR

Median scores and proportions of desired answers to each question related to participants’ knowledge are presented in Tables 2 and 3. VS scored significantly higher (14 ± 4) than NMS (10 ± 5) in their first and last year of study. Both last-year VS and NMS had higher scores than first-year students, with familiarity of antibiotics and AMR increasing in last-year VS (K2,4).

Table 2. Knowledge (K), attitudes (A) and practices (P) scores in veterinary and non-medical undergraduate students.

| Score | Median [IQR] | Whole | VS | NMS | p | First | Last | p | First | Last | p |
|-------|--------------|-------|----|-----|----|-------|------|----|-------|------|----|
| Knowledge | 12 [6] | 14 [4] | 10 [5] | <0.001 | 13 [4] | 16 [2] | <0.001 | 9 [5] | 11 [4] | <0.001 |
| Attitudes | 56 [13] | 59 [11] | 53 [14] | <0.001 | 57 [16] | 62 [8] | <0.001 | 51 [15] | 54 [12] | 0.003 |
| Practices | 7 [3] | 7 [3] | 6 [4] | <0.001 | 7 [4] | 7.5 [3] | 0.026 | 6 [5] | 7 [3] | 0.008 |

IQR = Interquartile range.

Table 3. Proportion of responses to questions about knowledge.

| Question | (Desirable Answer) | Whole | VS | NMS | p | First | Last | p | First | Last | p |
|----------|--------------------|-------|----|-----|----|-------|------|----|-------|------|----|
| K1. Do you know “antimicrobials”? (Yes) | 84.87 (2401) | 95.31 (1361) | 74.23 (1040) | <0.001 | 92.99 (252) | 98.86 (95) | 0.033 | 65.32 (162) | 69.4 (161) | 0.381 |
| K2. Are you familiar with the concept of antibiotics? (Yes) | 93.46 (2644) | 96.01 (1371) | 90.86 (1273) | <0.001 | 93.36 (253) | 100 (96) | 0.005 | 83.47 (207) | 90.09 (209) | 0.043 |
| K3. Do you think that antibiotics are different from antimicrobials? (Yes) | 73.84 (2089) | 78.85 (1126) | 68.74 (963) | <0.001 | 78.23 (212) | 82.29 (79) | 0.465 | 68.95 (171) | 62.5 (145) | 0.149 |
| K4. Do you know about antibiotic resistance? (Yes) | 83.74 (2369) | 89.15 (1273) | 78.23 (1096) | <0.001 | 77.12 (209) | 98.86 (95) | <0.001 | 65.73 (163) | 81.9 (190) | <0.001 |
| K5. What is your understanding of antibiotic resistance? (correct answer) | 68.33 (1933) | 80.04 (1143) | 56.39 (790) | <0.001 | 73.06 (198) | 80.21 (77) | 0.174 | 52.42 (130) | 61.64 (143) | 0.043 |
| K7. Do you know any antibiotics that are prohibited to use in human/livestock/fisheries/agriculture? (Yes) | 15.59 (441) | 18.63 (266) | 12.35 (173) | <0.001 | 16.97 (46) | 23.96 (23) | 0.184 | 17.74 (44) | 13.36 (31) | 0.31 |
| K8. Can antibiotics be used to cure infections caused by bacteria? (Yes) | 69.21 (1958) | 89.15 (1273) | 48.89 (685) | <0.001 | 91.88 (249) | 91.67 (88) | 1 | 64.52 (160) | 48.28 (112) | <0.001 |
| K9. Can antibiotics be used to cure infections caused by viruses? (No) | 59.21 (1675) | 69.82 (997) | 48.39 (678) | <0.001 | 67.53 (183) | 78.12 (75) | 0.052 | 40.73 (101) | 53.88 (125) | 0.005 |
| K10. Do you think the use of antibiotics will speed up the recovery of cold, cough and other diseases caused by common flu virus? (No) | 47.97 (1357) | 56.79 (811) | 38.97 (546) | <0.001 | 60.89 (165) | 57.29 (55) | 0.547 | 36.29 (90) | 43.1 (100) | 0.136 |
The proportion of desirable answers was higher in VS compared to NMS for all questions. While a majority of students in both groups knew about antibiotics (K2), VS had a better understanding of AMR than NMS (K4,6) and could better identify antibiotics (K15). Large differences were also observed for questions K8, 9 and 10, with a much greater proportion of VS being aware that antibiotics could be used against bacteria (89.15% vs. 48.89%) but not against viruses (69.82% vs. 48.39%) compared to NMS, suggesting a greater confusion between viruses and bacteria in NMS. Only 38.97% of NMS believed that antibiotics would not speed up the recovery of common cold compared to 56.79% of VS.

Responses to questions K11 and K14 suggested discrepancies between the existing regulation on antibiotics purchases and use, and its enforcement. Despite a large majority of VS (93.49%) and NMS (88.72%) agreeing that antibiotics should be used according to a professional’s guidelines, 47.13% and 41.54% reported that antibiotics could be obtained without prescription at pharmacies. Interestingly, this proportion was significantly higher in VS. Furthermore, only 44.68% of VS and 36.55% of NMS declared that antibiotics could not be used for disease prevention. Few students were able to mention any prohibited antibiotics.

The academic curriculum was the most prevalent source of information about antibiotics among students from both groups, followed by social networks, newspaper and television (Table 4). VS relied significantly more on their curriculum and veterinary professionals while NMS relied more on television.
Table 4. Sources of information about antibiotics resistance.

| Source of Information | % (n) Whole (N = 2829) | % (n) VS (N = 1428) | % (n) NMS (N = 1401) | p  |
|-----------------------|------------------------|---------------------|----------------------|----|
| Academic curriculum   | 57.83 (1636)           | 70.17 (1002)        | 45.25 (634)          | < 0.001 |
| Social network        | 34.57 (978)            | 35.43 (506)         | 33.69 (472)          | 0.343 |
| Newspaper             | 25.31 (716)            | 26.96 (385)         | 23.63 (331)          | 0.042 |
| Television            | 19.69 (557)            | 17.58 (251)         | 21.84 (306)          | 0.005 |
| Veterinary doctor     | 18.52 (524)            | 30.53 (436)         | 6.28 (88)            | < 0.001 |
| Human doctor          | 15.73 (445)            | 16.32 (233)         | 15.13 (212)          | 0.409 |
| Drug seller           | 4.49 (127)             | 3.99 (57)           | 5.00 (70)            | 0.205 |
| Radio                 | 4.35 (123)             | 4.55 (65)           | 4.14 (58)            | 0.645 |
| Para vet              | 1.91 (54)              | 2.94 (42)           | 0.86 (12)            | < 0.001 |
| Other                 | 4.42 (125)             | 3.50 (50)           | 5.35 (75)            | 0.017 |

2.3. Attitudes Regarding Antibiotics

The proportions of desirable answers to questions exploring attitudes are presented in Table 5. VS answered all questions significantly better with a median score of 59 compared to 53 for NMS. Awareness of AMR (A1,2) and risky practices (A14,15) improved in both groups from first to last year of study. Final-year VS were more aware than first-year students of the importance of vaccination in disease prevention (97.92% compared to 90.04%) and how it can help reduce the use of antibiotics (93.75% and 80.07%), while there was no difference in NMS. It is noteworthy that unlike VS, a majority of NMS seemed to support the use of antibiotics as growth promoters in livestock production.

Table 5. Proportion of responses to questions about attitudes.

| Question (Desirable Answer)                  | Whole       | VS          | NMS         | p  |
|----------------------------------------------|-------------|-------------|-------------|----|
| % (n) Total (N = 2829)                       | % (n) VS (N = 1428) | % (n) NMS (N = 1401) | p | % (n) First (N = 248) | % (n) Last (N = 232) | p |
| A1. Antibiotic resistance is a problem in Bangladesh (Yes) | 91.09 (2577) | 95.03 (1357) | 87.08 (1220) | <0.001 | 92.62 (251) | 98.96 (95) | 0.020 | 84.27 (209) | 90.95 (211) | 0.028 |
| A2. At present, there is abuse on antibiotics (Yes) | 89.47 (2531) | 92.30 (1318) | 86.58 (1213) | <0.001 | 91.51 (246) | 97.92 (94) | 0.033 | 83.47 (207) | 90.52 (210) | 0.030 |
| A3. Antibiotic resistance can affect you and your family’s health (Yes) | 78.19 (2212) | 80.95 (1156) | 75.37 (1056) | <0.001 | 81.92 (223) | 94.79 (91) | 0.001 | 76.21 (189) | 70.69 (164) | 0.180 |
| A4. It is necessary to get more information about antibiotics (Yes) | 92.22 (2699) | 94.47 (1349) | 89.94 (1260) | <0.001 | 91.88 (249) | 97.92 (94) | 0.052 | 89.92 (223) | 89.22 (207) | 0.881 |
| A5. When a disease in an individual can’t be treated with antibiotics, how serious do you think it could be? (serious, very serious) | 82.01 (2350) | 84.73 (1210) | 79.23 (1110) | <0.001 | 88.93 (241) | 87.50 (84) | 0.711 | 74.6 (185) | 81.03 (188) | 0.100 |
| A6. When a disease in an animal can’t be treated with antibiotics, how serious do you think it could be? (serious, very serious) | 85.12 (2408) | 87.54 (1250) | 82.66 (1158) | <0.001 | 91.88 (249) | 86.46 (83) | 0.155 | 80.65 (200) | 82.33 (191) | 0.641 |
| A7. Should antibiotics be used only when prescribed by doctors? (Yes) | 92.82 (2626) | 95.31 (1361) | 90.29 (1265) | <0.001 | 95.94 (260) | 97.92 (94) | 0.527 | 83.06 (206) | 92.67 (215) | 0.001 |
| Table 5. Cont. | Question (Desirable Answer) | Whole | VS | NMS |
|----------------|----------------------------|-------|----|-----|
| A8.            | Do you think vaccination can prevent diseases? (Yes) | 87.80 (2484) | 91.53 (1307) | 84.01 (1177) | <0.001 | 90.04 (244) | 97.92 (94) | 0.014 | 83.47 (207) | 84.05 (195) | 0.902 |
| A9.            | Do you think vaccination can help reduce the use of antibiotics? (Yes) | 83.32 (2357) | 87.18 (1245) | 79.37 (1112) | <0.001 | 80.07 (217) | 93.75 (90) | 0.001 | 75.81 (188) | 79.31 (184) | 0.383 |
| A10.           | Is it necessary to establish a course on “Rational use of antibiotics” at the university level? (Yes) | 86.14 (2437) | 89.29 (1275) | 82.94 (1162) | <0.001 | 91.88 (249) | 95.83 (92) | 0.250 | 82.66 (205) | 85.34 (198) | 0.457 |
| A11.           | Please rate your interest in learning more about antibiotics (interested, very interested) | 90.00 (2546) | 93.07 (1329) | 86.87 (1217) | <0.001 | 90.77 (246) | 96.88 (93) | 0.071 | 84.68 (210) | 86.64 (201) | 0.603 |
| A12.           | Have you ever attended any training/conference/seminar/workshop on antibiotics? (Yes) | 25.87 (732) | 36.27 (518) | 15.27 (214) | <0.001 | 36.38 (104) | 61.46 (59) | <0.001 | 20.16 (50) | 10.78 (25) | 0.005 |
| A13.           | Have you ever attended any training/conference/seminar/workshop on antibiotic resistance? (Yes) | 25.98 (735) | 36.90 (527) | 14.85 (208) | <0.001 | 42.07 (114) | 57.29 (55) | 0.012 | 22.18 (55) | 11.21 (26) | 0.001 |
| A14-1.         | Antibiotics protect both humans and animals (livestock, fisheries) (agree, strongly agree) | 79.36 (2245) | 85.85 (1226) | 72.73 (1019) | <0.001 | 85.24 (231) | 91.67 (88) | 0.117 | 65.73 (163) | 80.6 (187) | <0.001 |
| A14-2.         | Antibiotics abuse is the main cause of bacterial resistance (agree, strongly agree) | 76.86 (2146) | 85.15 (1216) | 66.38 (930) | <0.001 | 83.76 (227) | 96.88 (93) | 0.001 | 55.24 (137) | 71.12 (165) | <0.001 |
| A14-3.         | When using antibiotics correctly, there is less risk of antibiotic resistance (agree, strongly agree) | 76.67 (2169) | 83.19 (1188) | 70.02 (981) | <0.001 | 78.97 (214) | 89.58 (86) | 0.021 | 65.73 (163) | 75.43 (175) | 0.022 |
| A14-4.         | It is important to use antibiotics as growth promoters in livestock production (disagree, strongly disagree) | 52.17 (1476) | 60.92 (870) | 43.25 (606) | <0.001 | 49.45 (134) | 66.67 (64) | 0.004 | 37.1 (92) | 48.28 (112) | 0.016 |
| A14-5.         | It is important to use antibiotics as growth promoters in the livestock & fisheries sector (disagree, strongly disagree) | 55.00 (1556) | 62.32 (890) | 47.54 (666) | <0.001 | 53.14 (144) | 71.88 (69) | 0.002 | 43.95 (109) | 54.31 (126) | 0.028 |
| A14-6.         | Inappropriate use or half course of antibiotics leads to antibiotics resistance (agree, strongly agree) | 71.12 (2012) | 78.78 (1125) | 63.31 (887) | <0.001 | 66.05 (179) | 85.42 (82) | <0.001 | 53.63 (133) | 68.1 (158) | 0.001 |
| A15-1.         | Apply hygiene and biosecurity measure in livestock & fisheries activities (agree, strongly agree) | 82.71 (2340) | 91.11 (1301) | 74.16 (1039) | <0.001 | 85.24 (231) | 97.92 (94) | <0.001 | 64.92 (161) | 81.03 (188) | <0.001 |
The results also showed that VS were provided more extra-curricular opportunities to learn about antibiotics and AMR (A12,13). The proportion of VS who had attended a workshop or seminar on antibiotics increased significantly from first (38.38%) to final year (61.46%) while it decreased from 20.16% to 10.78% in NMS.

Taking into consideration the particular role of agriculture students (AS) regarding the use of antibiotics in livestock, we conducted an additional analysis to further explore related attitudes in this group. The results, which are provided in Appendix A, showed that AS had lower KAP scores than VS and that their A and P scores did not significantly improve from first to final year despite better K scores. The proportions of desirable answers to questions A14 and A15, which explored more specifically the use of antibiotics in food animals, was significantly lower in AS compared to VS. In particular, a higher proportion of AS considered the use of antibiotics as growth promotors in livestock as important.

### Table 5. Cont.

| Question (Desirable Answer) | Whole | VS | NMS | | Whole | VS | NMS | | Whole | VS | NMS | |
|----------------------------|-------|----|-----|| % (n) | % (n) | % (n) | P | % (n) | % (n) | % (n) | P | % (n) | % (n) | % (n) | P |
| A15-2. Apply appropriately/fully vaccination of human/animals (agree, strongly agree) | 81.55 (2307) | 88.80 (1268) | 74.16 (1039) | <0.001 | 84.13 (226) | 97.92 (94) | <0.001 | 65.32 (162) | 79.74 (185) | 0.001 |
| A15-3. Using antibiotic/antimicrobial by following guideline, description, and regulation (agree, strongly agree) | 79.57 (2251) | 87.11 (1244) | 71.88 (1007) | <0.001 | 82.29 (223) | 96.88 (93) | <0.001 | 64.11 (159) | 75.43 (175) | 0.007 |
| A15-4. Farmers need to be provided drug description and treatment by veterinarian/authorities when they buy/use antibiotic (agree, strongly agree) | 78.19 (2212) | 86.83 (1240) | 69.38 (972) | <0.001 | 81.92 (222) | 95.83 (92) | 0.001 | 60.08 (149) | 73.28 (170) | 0.003 |
| A15-5. Ensure a sufficient/appropriate withdrawal time before selling to avoid antibiotic residue in food animal (agree, strongly agree) | 75.57 (2138) | 84.45 (1206) | 66.52 (932) | <0.001 | 74.17 (201) | 96.88 (93) | <0.001 | 58.47 (145) | 71.98 (167) | 0.002 |
| A15-6. Everyone should follow full course of antibiotics (agree, strongly agree) | 79.22 (2241) | 87.54 (1250) | 70.74 (991) | <0.001 | 81.92 (222) | 95.83 (92) | 0.001 | 64.11 (159) | 73.28 (170) | 0.039 |

### 2.4. Practices Regarding Antibiotics Use

The proportions of desirable answers to questions about practices are presented in Table 6. First (median score: 7) and last year (7.5) VS had significantly higher scores than NMS (6 and 7, respectively). NMS were more likely to use antibiotics for common flu symptoms such as fever, coughing or obstructed nose (P8) and were less mindful of the expiry date (P4,5).

Some practices considered to be at risk for AMR were common among both groups. Self-medication was prevalent in similar proportions among VS and NMS (P2), and only 56.23% of VS and 52.39% of NMS completed their full course of treatment without interrupting it once they felt better (P1). Interestingly, this proportion decreased from first (60.15%) to last year VS (46.88%). Last year VS were also more likely to use antibiotics without instructions but less against common flu symptoms. Some participants (18.13%) reported keeping leftover antibiotics for future use or disposed of these inappropriately (P7).
Table 6. Proportion of responses to questions about practices.

| Question (Desirable Answer) | Whole (N = 2829) | Whole VS (N = 1428) | Whole NMS (N = 1401) | P     | VS (N = 271) | NMS (N = 232) | P     |
|-----------------------------|------------------|---------------------|----------------------|-------|---------------|---------------|-------|
| P1. Do you stop the use of antibiotics as soon as you feel better? (No) | 54.33 (1537)     | 56.23 (803)        | 52.39 (734)          | 0.042 | 60.15 (163)   | 46.88 (45)    | 0.031 |
| P2. Do you use antibiotics without the doctor’s instructions? (No) | 70.2 (1986)      | 71.15 (1016)       | 69.24 (970)          | 0.267 | 75.28 (204)   | 61.46 (59)    | 0.012 |
| P3. Do you ask the doctor to prescribe antibiotics for a common cold? (No) | 72.43 (2049)     | 73.25 (1046)       | 71.59 (1003)         | 0.333 | 70.85 (192)   | 62.5 (60)     | 0.159 |
| P4. Do you check expired date of antibiotics before using? (Yes) | 83.95 (2375)     | 86.76 (1239)       | 81.08 (1136)         | <0.001 | 87.82 (238)   | 96.88 (93)    | 0.009 |
| P5. If the antibiotic was expired, what would you do? (Stop using) | 84.16 (2381)     | 87.32 (1247)       | 80.94 (1134)         | <0.001 | 86.35 (234)   | 96.88 (93)    | 0.004 |
| P6. Which factors do you prioritize when buying antibiotics? | 58.57 (1657)     | 65.62 (957)        | 51.39 (720)          | <0.001 | 67.16 (182)   | 69.79 (67)    | 0.703 |
| Expiry date | 10.64 (301)      | 7.77 (111)         | 13.56 (190)          | <0.001 | 5.90 (16)     | 11.46 (11)    | 0.108 |
| Brand/trademark | 16.30 (461)    | 15.76 (225)        | 16.85 (236)          | 0.445 | 15.13 (41)    | 9.38 (9)      | 0.171 |
| Drug seller’s recommendations | 8.80 (249)       | 6.72 (96)          | 10.92 (153)          | <0.001 | 8.86 (24)     | 5.21 (5)      | 0.378 |
| Family, friends or neighbors recommendations | 5.16 (146)       | 3.99 (57)          | 6.35 (89)            | 0.005 | 2.95 (8)      | 3.12 (3)      | 1     |
| P7. What do you do with leftover antibiotics? | 41.68 (1179)     | 40.76 (582)        | 42.61 (597)          | 0.322 | 38.01 (103)   | 56.25 (54)    | 0.003 |
| Throw in garbage | 17.32 (491)     | 21.43 (306)        | 13.13 (184)          | <0.001 | 23.99 (65)    | 9.38 (9)      | 0.002 |
| Bury in the ground | 15.52 (439)     | 18.49 (264)        | 12.49 (175)          | <0.001 | 15.87 (43)    | 16.67 (16)    | 0.872 |
| Keep for future use | 4.67 (132)       | 4.62 (66)          | 4.71 (66)            | 0.929 | 5.54 (15)     | 3.12 (3)      | 0.423 |
| Other | 18.13 (513)      | 19.33 (57)         | 16.92 (237)          | 0.097 | 25.46 (69)    | 15.62 (15)    | 0.049 |
| P8. Do you use antibiotics for the following cases? (Yes) | 61.89 (1751)     | 69.61 (994)        | 54.03 (757)          | <0.001 | 66.79 (181)   | 88.54 (85)    | <0.001 |
| Fever (less than 38.5°C) | 74.27 (2101)    | 81.37 (1162)       | 67.02 (939)          | <0.001 | 78.97 (214)   | 92.71 (89)    | 0.002 |
| Common cold | 44.75 (1266)    | 46.85 (669)        | 42.61 (597)          | 0.026 | 51.29 (139)   | 62.50 (60)    | 0.073 |
| Coughing up yellow/green phlegm | 59.07 (1671)    | 64.01 (914)        | 54.03 (757)          | <0.001 | 62.36 (169)   | 84.38 (81)    | <0.001 |
| Obstructed nose with headache | 23.33 (660)      | 21.78 (311)        | 24.91 (349)          | 0.051 | 14.02 (38)    | 24.00 (24)    | 0.017 |

When buying antibiotics, most respondents noticed the expiry date but NMS were more likely than VS to buy antibiotics according to the drug seller or relatives’ recommendations (P6).

2.5. Factors Influencing Knowledge, Attitudes and Practices

Results of the univariable and multivariable analysis are presented in Table 7. The academic curriculum and the year of study were the only factors statistically associated with all three KAP scores in multivariable analysis. Attitude scores were also found to increase with the age of respondents. Post-hoc comparison using Dunn’s test showed that first-year students had significantly lower KAP scores than last-year and master’s students (p-value < 0.05), while there was no significant difference between last-year and master’s students.
Table 7. Knowledge (K), attitudes (A) and practices (P) scores with respect to demographics.

| Variable          | K Scores | p (Uni-variable) | est. ± SD (p) (Multivariable) | A Scores | p (Uni-variable) | est. ± SD (p) (Multivariable) | P Scores | p (Uni-variable) | est. ± SD (p) (Multivariable) |
|-------------------|----------|------------------|-------------------------------|----------|------------------|-------------------------------|----------|------------------|-------------------------------|
| Category *        |          |                  |                               |          |                  |                               |          |                  |                               |
| Veterinary students (N = 1428) | 14 [4]  <0.001 | 0.270 ± 0.020 (<0.001) | 59 [11] <0.001 | 0.131 ± 0.012 (<0.001) | 7 [3] <0.001 | 0.122 ± 0.027 (<0.001) |          |                  |                               |
| Non-medical students (N = 1401) | 10 [5]  |                  |                               |          |                  |                               |          |                  |                               |
| Gender *          |          |                  |                               |          |                  |                               |          |                  |                               |
| Female (N = 1197) | 12 [5]  <0.001 | reference | 56 [13] 0.003 ± 0.020 (0.879) | 57 [13] 0.012 | - | 7 [3] 0.015 ± 0.012 (0.201) | 7 [3] 0.276 | - |                               |
| Male (N = 1632)   | 13 [5]  <0.001 | reference | 54 [13] 0.089 ± 0.033 (0.008) | 57 [12] <0.001 | - | 7 [3] 0.049 ± 0.020 (0.015) | 7 [3] 0.22 | - |                               |
| Age **            |          |                  |                               |          |                  |                               |          |                  |                               |
| 17–20 (N = 802)   | 11 [5]  <0.001 | reference | 54 [13] 0.059 ± 0.046 (0.196) | 58.5 [10.75] | - | 7 [3] 0.060 ± 0.028 (0.031) | 7 [3] | - |                               |
| 21–24 (N = 1877)  | 13 [5]  <0.001 | reference | 52 [13] 0.077 ± 0.035 (0.039) | 57 [13] 0.001 | - | 7 [3] 0.020 ± 0.021 (0.351) | 7 [3] 0.016 | - | 0.100 ± 0.029 (<0.001) |
| 25 + (N = 150)    | 14 [4]  <0.001 | reference | 53 [14] 0.108 ± 0.044 (0.013) | 56 [8.25] | - | 7 [3] 0.055 ± 0.007 (0.004) | 7 [3] | - | 0.139 ± 0.040 (<0.001) |
| Year **           |          |                  |                               |          |                  |                               |          |                  |                               |
| First (N = 519)   | 11 [5]  <0.001 | reference | 53 [14] 0.072 ± 0.035 (0.039) | 57 [13] 0.001 | - | 7 [3] 0.020 ± 0.021 (0.351) | 7 [3] 0.016 | - | 0.100 ± 0.029 (<0.001) |
| Last (N = 328)    | 13 [5]  <0.001 | reference | 56 [13] 0.108 ± 0.044 (0.013) | 56 [8.25] | - | 7 [3] 0.055 ± 0.007 (0.004) | 7 [3] | - | 0.139 ± 0.040 (<0.001) |
| Masters (N = 124) | 13 [4.25] <0.001 | reference | 53 [14] 0.108 ± 0.044 (0.013) | 56 [8.25] | - | 7 [3] 0.055 ± 0.007 (0.004) | 7 [3] | - | 0.139 ± 0.040 (<0.001) |

Scores are presented as median [interquartile range]. Results of the multivariable analysis are presented as estimate ± standard deviation, * Mann Whitney U test, ** Kruskal Wallis test.

2.6. Association between Knowledge, Attitudes and Practices

Spearman’s rank correlation coefficient showed that the scores for K, A and P were significantly positively correlated (Table 8), with the association being stronger between knowledge and attitudes and weaker between knowledge and practices.

Table 8. Spearman’s correlation coefficient between knowledge, attitudes and practices.

| Variable | Knowledge | Attitudes | Practices |
|----------|-----------|-----------|-----------|
| Knowledge | -         | -         | -         |
| Attitudes | 0.515 (<p < 0.001) | - | - |
| Practices | 0.322 (<p < 0.001) | 0.422 (<p < 0.001) | - |

3. Discussion

To our knowledge, this is the first study investigating knowledge, attitudes and practices regarding antibiotics and AMR in veterinary students in Bangladesh. Our results showed that VS had better KAP compared to NMS, suggesting a positive impact of veterinary education, with KAP scores improving significantly over the curriculum. In particular, senior VS were more familiar with the concept of AMR and aware of the importance of vaccination to reduce antibiotic use in animals. They were also more aware of risky practices. In line with other studies, the academic background, age and year of study were identified as factors influencing KAP [21,25,26,36].

However, this study highlighted important gaps in knowledge about antibiotics among VS. About a third of VS did not know that antibiotics were ineffective against viruses and only 56.79% believed antibiotics could not speed up the recovery of common cold. Similar proportions have been observed among medical students in previous studies in India, China, Jordan and the United Arab Emirates [12,19,22,23,36]. The large proportions of students who were aware that antibiotics could be obtained without prescription at pharmacies and used for prophylaxis might reflect current practices in the field, and the lack of regulatory enforcement over drug sales in Bangladesh. This confirms the need to improve educational training on antibiotics and AMR in the veterinary curriculum. Additionally, creating awareness campaigns on social media could be an interesting approach given the high proportion of students who rely on it as a source of information.
Evidence of improper practices were also found among VS. While self-medication seemed to be less prevalent than reported by other studies in medical students [21,36], almost half of VS were likely to interrupt treatment before its completion if they felt better. Most respondents disposed of left-over antibiotics inappropriately by burying or throwing them together with household waste, which increases the risk of environmental contamination [6,37]. Almost a fifth kept leftovers for future use, presumably without proper guidelines.

Additionally, although K, A and P were found to be statistically positively correlated, the translation of better knowledge and attitudes into adequate practices was not consistent. While knowledge and attitudes improved over the curriculum, self-medication and early interruption of treatment were more prevalent in senior VS compared to first-year students, suggesting inadequate training on rational antibiotic use during their studies. This supports the findings of previous investigations in medical students and professionals, which have highlighted a similar discrepancy between knowledge and practices [4,12,21,25,36]. However, they appeared to be less likely to inappropriately use antibiotics against common cold symptoms. This could indicate a greater familiarity with their indications, as suggested by several studies in medical students [18,21,25,36].

Overall, our study demonstrates the need to strengthen the veterinary curriculum in Bangladesh. Currently, nine institutions are offering veterinary degrees but the nomenclature for degrees, curricula and syllabuses vary from one another and international standards are not well established. Efforts are being made to meet the OIE-recommended core curriculum [38].

This study has several limitations. First, participants were recruited through opportunistic sampling, which might limit the representativeness of the sample. It is particularly worth noting that a significant proportion of the NMS interviewed in this survey were in agricultural faculties, and therefore, their opinion on non-human antibiotic use might not reflect that of the general population. This potential bias must be accounted for when looking, for instance, at the high proportion of NMS who supported the use of antibiotics for growth promotion or prophylaxis. The additional analysis we conducted in agriculture students showed that their A and P scores did not significantly improve from first to final year despite better knowledge, and revealed poorer attitudes regarding the use of antibiotics in livestock compared to VS. Considering the impact of their future professional practices on AMR, it would be relevant to conduct similar surveys in this group. Reporting bias can also not be ruled out, especially for questions about practices, as participants might be more inclined to give what they considered to be the “correct” answer rather than an accurate description of their behaviors. Nevertheless, a large proportion of students still reported inadequate practices.

Additionally, while ensuring appropriate prescription practices in veterinarians is essential to mitigate the spread of AMR, their influence on consumers might be limited. Other studies have shown that farmers actually had little interactions with veterinarians and purchased drugs from unlicensed village doctors [33,34]. This corroborates our results showing that NMS relied mostly on sellers or relatives’ recommendations rather than professionals when buying antibiotics. Finally, it is important to acknowledge that the determinants of antibiotic use are multifactorial and that improving awareness alone is unlikely to produce sustainable results. Other barriers remain that might prevent the adoption of adequate practices despite proper knowledge including the lack of regulation frameworks and resources for their implementation, inadequate diagnostic tools and high prevalence of counterfeit drugs in LMIC [4,20,26,32].
4. Material and Methods

4.1. Study Design

A cross-sectional survey was carried out from November 2019 to March 2020 to investigate knowledge, attitudes and practices (KAP) regarding antibiotic use among 3002 students from 12 of the 53 public universities in Bangladesh using a paper-based self-administered questionnaire (Table S1). Universities were selected with the initial aim of including at least one university per Division and prioritize universities with both veterinary and non-veterinary faculties. The final selection included eight universities with both categories of faculties, three with only non-veterinary faculties and one with only a veterinary faculty in seven of the eight Divisions of Bangladesh. Veterinary students (VS) and students from non-medical faculties (NMS) (Agriculture, Business, Art, Mathematics or other sciences) were recruited through opportunistic sampling on a voluntary basis. A minimum sample size of 384 students was calculated using the formula \( n = \frac{Z^2p(1-p)}{d^2} \) with a significance level \( \alpha \) of 5%, precision \( d \) of 5% and expected prevalence of correct answers \( P \) of 0.5 [39]. The size was inflated to account for potential drop-outs and increase the significance of results.

This study received ethical approval from the Ethical Committee of the Animal Health Research Division at the Bangladesh Livestock Research Institute (ARAC:15/10/2019:02).

4.2. Questionnaire Design and Grading Method

A pilot survey was performed prior to the main study to assess the relevance and understandability of the questionnaire. Minor revisions were made afterwards. The final questionnaire included four sections: (1) collection of participants’ characteristics (age, gender, faculty, university); (2) 15 questions on knowledge about antibiotics and sources of information; (3) 15 questions exploring attitudes regarding antibiotics; and (4) 8 questions investigating practices regarding the use of antibiotics. Questions in the knowledge and practices sections were classified as “desirable” and “non-desirable” (including missing answers) and awarded 1 or 0 points accordingly. Likert scale questions in the attitude section were awarded 0 to 4 points from “Strongly incorrect” to “Strongly correct”. The grading method is summarized in Table S2. Qualitative questions that could not be graded (K5, P6 and P7) were not considered for scoring.

4.3. Data Collection

Ten enumerators were trained to collect the data. Before delivering the questionnaire, they explained the study objectives and required informed consent from all students who agreed to participate. All respondents had the opportunity to withdraw themselves from the study at any point. Individual questionnaires were anonymized and identified using the name of the faculty and a registration number. The data was managed using Microsoft Excel [40].

4.4. Data Analysis

Questionnaires with less than 70% questions answered and students from other medical faculties were not included in the analysis. Descriptive statistics and Fisher’s exact test were used to analyze and compare the characteristics of VS and NMS. Categorical variables were expressed as percentages, continuous variables as the mean ± standard deviation and discrete variables as the median and associated interquartile range (IQR). The proportions of answers to each categorical KAP question were compared between VS and NMS using Fisher’s exact test. The Shapiro–Wilcoxon test allowed us to reject the hypothesis of normal distribution of KAP scores (\( p\)-value < 0.001). Mann–Whitney U and Kruskal Wallis tests were used to identify factors associated with KAP scores in univariate analysis, and Spearman’s rho was used to explore the association between KAP scores. Multivariable analysis was carried out using a negative binomial regression model to account for overdispersion of the data. A \( p\)-value < 0.05 was taken as statistically significant. All analyses were performed using R [41].
5. Conclusions

Our study revealed critical gaps in KAP regarding antibiotic use and resistance in veterinary students that are likely to contribute to inappropriate use in the future. This indicates deficiencies in their training and confirms the need to strengthen educational programs on AMR in the veterinary curriculum. While improving awareness and understanding of AMR to promote rational use in professionals is an important component of mitigation strategies, it needs to be supported by policies through the implementation of formal frameworks and enforcement of regulation across all sectors. Therefore, educational interventions must be embedded in a multi-sectoral strategy involving policymakers, health practitioners, animal production stakeholders, pharmaceutical companies and consumers to effectively address the issue of AMR in a “one health” approach.

Supplementary Materials: The following are available online at https://www.mdpi.com/2079-6382/10/3/332/s1, Table S1: List of universities; Table S2: Scoring method.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethical Committee of the Animal Health Research Division at the Bangladesh Livestock Research Institute (ARAC:15/10/2019:02).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Knowledge (K), Attitudes (A) and Practices (P) scores in veterinary and agriculture undergraduate students.

| Score (Median [IQR]) | Whole (n = 2829) | VS (n = 1428) | AS (n = 805) | p  | First (n = 271) | Last (n = 96) | p  | First (n = 156) | Last (n = 134) | p  |
|-----------------------|------------------|--------------|-------------|----|----------------|---------------|----|----------------|----------------|----|
| Knowledge             | 12 [6]           | 14 [4]       | 11 [5]      | <0.001 | 13 [5]       | 16 [2]        | <0.001 | 11.5 [4]     | 11 [5]         | 0.012 |
| Attitudes             | 56 [13]          | 59 [11]      | 55 [10]     | <0.001 | 57 [16]      | 62 [8]       | <0.001 | 53 [10]      | 55 [10]        | 0.146 |
| Practices             | 7 [3]            | 7 [3]        | 7 [3]       | 0.011 | 7 [4]        | 7.5 [3]      | 0.026 | 6 [4]         | 7 [3]          | 0.265 |
Table A2. Proportion of responses to questions about attitudes in veterinary and agriculture students.

| Question about Attitudes (Desirable Answer) | Whole | VS (N = 1428) | AS (N = 805) | p |
|---------------------------------------------|-------|---------------|--------------|---|
| A14-1. Antibiotics protect both humans and animals (livestock, fisheries) (agree, strongly agree) | 85.85 (1226) | 80.99 (652) | 0.003 |
| A14-2. Antibiotics abuse is the main cause of bacterial resistance (agree, strongly agree) | 85.15 (1216) | 73.88 (393) | <0.001 |
| A14-3. When using antibiotics correctly, there is less risk of antibiotic resistance (agree, strongly agree) | 83.19 (1188) | 79.50 (640) | 0.034 |
| A14-4. It is important to use antibiotics as growth promoters in livestock production (disagree, strongly disagree) | 60.92 (870) | 50.31 (405) | <0.001 |
| A14-5. It is important to use antibiotics as growth promoters in the livestock & fisheries sector (disagree, strongly disagree) | 62.32 (890) | 55.40 (446) | 0.001 |
| A14-7. Inappropriate use or half course of antibiotics leads to antibiotics resistance (agree, strongly agree) | 78.78 (1125) | 72.30 (582) | 0.001 |
| A15-1. Apply hygiene and biosecurity measure in livestock & fisheries activities (agree, strongly agree) | 91.11 (1301) | 85.47 (688) | <0.001 |
| A15-2. Apply appropriately/fully vaccination of human/animals (agree, strongly agree) | 86.80 (1268) | 86.09 (639) | 0.069 |
| A15-3. Using antibiotic/antimicrobial by following guideline, description, and regulation (agree, strongly agree) | 87.11 (1244) | 82.98 (668) | 0.008 |
| A15-4. Farmers need to be provided drug description and treatment by veterinarian/authorities when they buy/use antibiotic (agree, strongly agree) | 86.83 (1240) | 80.87 (651) | <0.001 |
| A15-5. Ensure a sufficient/appropriate withdrawal time before selling to avoid antibiotic residue in food animal (agree, strongly agree) | 84.45 (1206) | 79.13 (637) | 0.002 |
| A15-6. Everyone should follow full course of antibiotics (agree, strongly agree) | 87.54 (1250) | 82.98 (668) | 0.004 |

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